ENGIN STORAGE
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ENGINEERING

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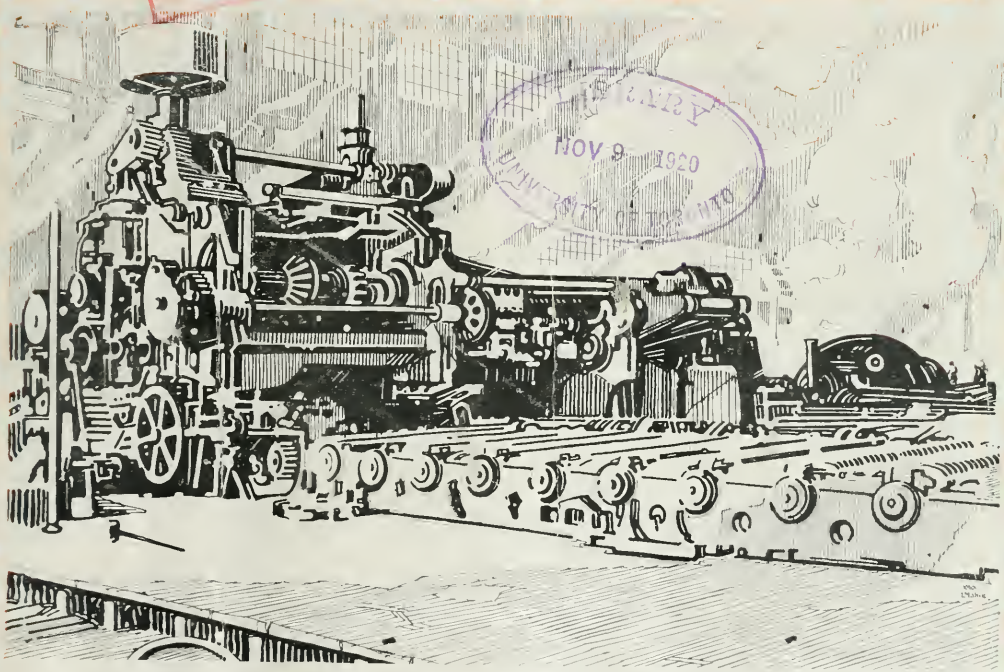
Entered as second class mail matter at Pittsburgh, Pa., under the Act of Congress, March 3, 1879

The Blast Furnace and Steel Plant

Pittsburgh, November, 1920.



MODERN PRACTICE

Recognizes the many advantages of Hyatt Roller Bearings for mill tables, ingot cars, charging cars, hot and cold saws, cranes and other equipment.

Read on pages 4 and 5 what other steel mill engineers are doing with Hyatt Roller Bearings.

HYATT ROLLER BEARING COMPANY. NEW YORK, N.Y.

A-1821

Economical Loading and Economical Unloading

Millions have been invested in labor saving devices for loading cars. Comparatively little has been invested in cars that can be unloaded without labor.

Loading devices have become essential because they replace expensive labor and conserve time. The same considerations make

Extension Side Dump Cars

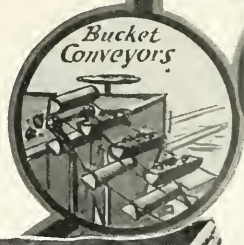
essential for waste disposal because they discharge their load without labor.

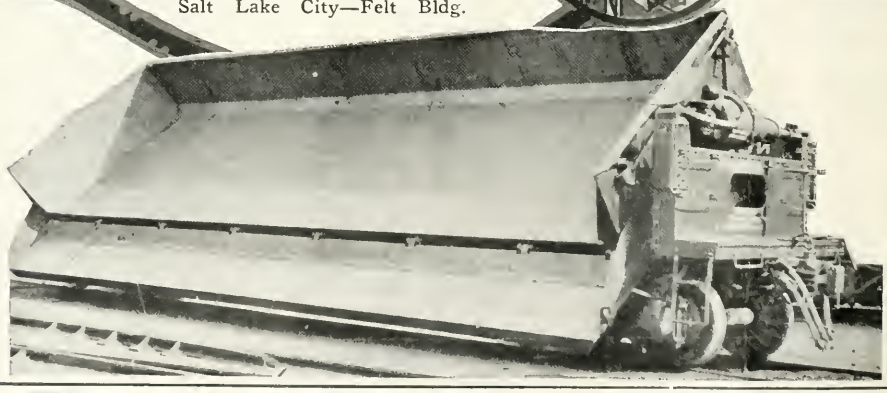
30 cu. yds. level full.
43 cu. yds. normal loading.
100,000 lbs. A. R. A. rating.

Clark Car Company
Pittsburgh

PITTSBURGH

Boston — 483 Atlantic Ave.
Chicago—Peoples Gas Bldg.
Salt Lake City—Felt Bldg.

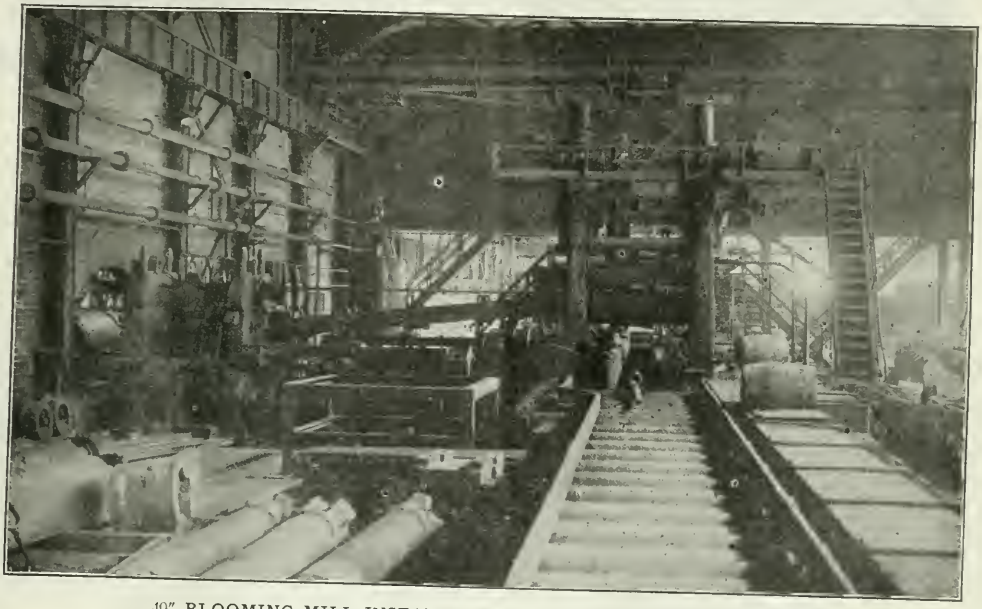




CLARK CARS

EXTENSION SIDE DUMP

"UNITED" BLOOMING MILLS



40" BLOOMING MILL INSTALLED AT McKINNEY STEEL COMPANY
Equipped With Every Improvement Known to the Art

"UNITED" Blooming Mills are Constructed for Continuous Operation and Maximum Production Brought About by

1—The well known "A" type housings.
2—Leck patented side guards.
3—United patented universal spindles and couplings.

Records on the above mill show the best hourly tonnage produced
Using 22" x 28" Ingots and reducing
same to 22" x 4" and 22" x 6" slabs
a total of 250 tons per hour.

These important features together with many other late improvements make "UNITED" Mills the best payers.

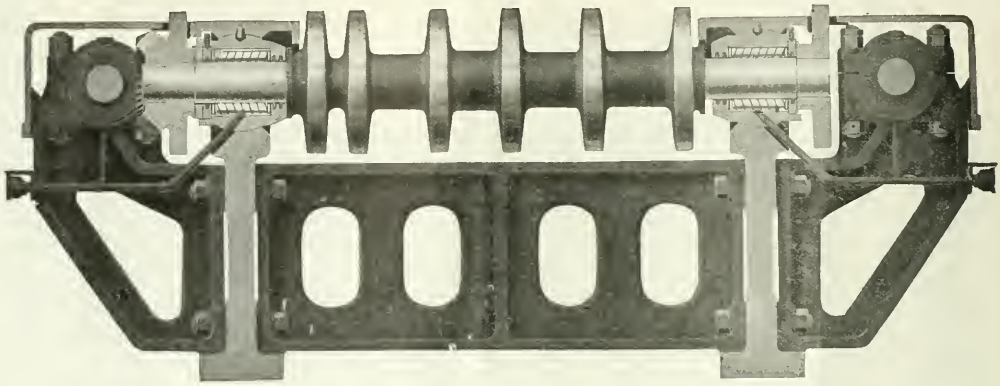
UNITED ENGINEERING & FOUNDRY COMPANY

PITTSBURGH, PA.

Write For Your Firm's Copy of "UNITED" Installation Bulletin I

Co-operate:—Refer to The Blast Furnace and Steel Plant

Hyatt Roller Bearings are Standard



Typical Hyatt Roller Bearing Equipped Plate Mill Tilting Table as manufactured by the United Engineering and Foundry Company, Pittsburgh, Pa.

The durability and dependability of Hyatt Roller Bearings for roller tables, together with their power, lubricant and maintenance saving advantages have made them standard bearing equipment for the approach, tilting and run-out tables of new mills and old mills.

The men responsible for the constant, high quality production of steel from the mills listed opposite know by actual experience what Hyatt Roller Bearings are doing for them.

It will pay you to investigate the advantages of Hyatt Roller Bearings for ***your*** mills.

Send for our complete steel mill bearing engineering data.

MOTOR BEARINGS DIVISION
DETROIT, MICHIGAN

HYATT ROLLER BEARING COMPANY
INDUSTRIAL BEARINGS DIVISION
NEW YORK, N. Y.

TRACTOR BEARINGS DIVISION
CHICAGO, ILLINOIS

Manufacturers of Bearings for Mine Cars, Ore Cars, Steel Mill Cars, Roller Tables, Trolleys, Cranes, Hoists, Machine Tools, Line Shafts, Countershafts, Concrete Machinery, Textile Machinery, Conveyors, Lift Trucks, Industrial Trucks, Railway Service Cars, Storage Battery Locomotives, etc

HYATT BEARINGS FOR

Co-operate.—Refer to The Blast Furnace and Steel Plant

in Modern Steel Mill Construction

Plate Mill Tilting Tables

Equipped with

Hyatt Roller Bearings

84″—Tandem 3-high—Brier Hill Steel Co., Youngstown, Ohio.
84″— " 3-high—Alan Wood Iron & Steel Co., Ivy Rock, Pa.
90″— " 3-high—Inland Steel Company, Indiana Harbor, Ind.
96″—3-high —Tata Iron & Steel Co., Saschki, India.
100″—3-high —Allegheny Steel Co., Brackenridge, Pa.
110″—3-high —Dominion Iron & Steel Co., Sydney, Nova Scotia, Canada.
110″—3-high —Tennessee Coal, Iron & R. R. Co., Birmingham, Ala.
110″—3-high —National Tube Company, McKeesport, Pa.
110″—3-high —Carnegie Steel Co., Homestead, Pa.
132″—3-high —Brier Hill Steel Co., Youngstown, Ohio.
134″—No. 1 3-high —Cambria Steel Co., Johnstown, Pa.
134″—No. 2 3-high —Cambria Steel Co., Johnstown, Pa.

Blooming Mill Tables

32″—2-high —Carnegie Steel Co., Mingo Junction, O.
34″—3-high —Treadwell Engineering Co., Easton, Pa.
(All approach, tilting and run-out tables of this mill are equipped with Hyatt Bearings.)
35″—3-high —John A. Roebling's Sons Co., Trenton, N. J.
30″—3-high Billet Mill—Bethlehem Steel Co., Saucon Plant, Bethlehem, Pa.

Bar and Hoop Mill Tables

1-12″ Bar Mill—Central Steel Company, Massillon, O.
9 mills—1- 8″ " " Carnegie Steel Company, Youngstown, O.
1-10″ " " " " " "
1-14″ " " " " " "
1-18″ " " " " " "
2- 8″ Hoop " " " " "
2-10″ " " " " " "
1-12″ " " " " " "

28″ Tandem — Tennessee Coal, Iron & R. R. Co., Birmingham, Ala. (Combination structural and bar mill, completely Hyatt equipped.)

Strip Mill Tables

18″—Band Mill —Carnegie Steel Company, Youngstown, O.
18″—Merchant Mill—Canton Sheet Steel Company, Canton, O.
16″—Flat Mill —American Steel & Wire Co., Cuyahoga Works, Cleveland, O.

There are also 2910 Hyatt Roller Bearing equipped Ingot and Charging Box Cars and 35,806 Hyatt Plate Castors in operation in the prominent steel mills of this country and abroad.

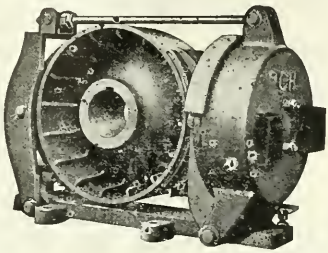
A-1822

STEEL MILL EQUIPMENT

Co-operate:—Refer to The Blast Furnace and Steel Plant

C-H

Where Are *You* Using C-H Type M Brakes?

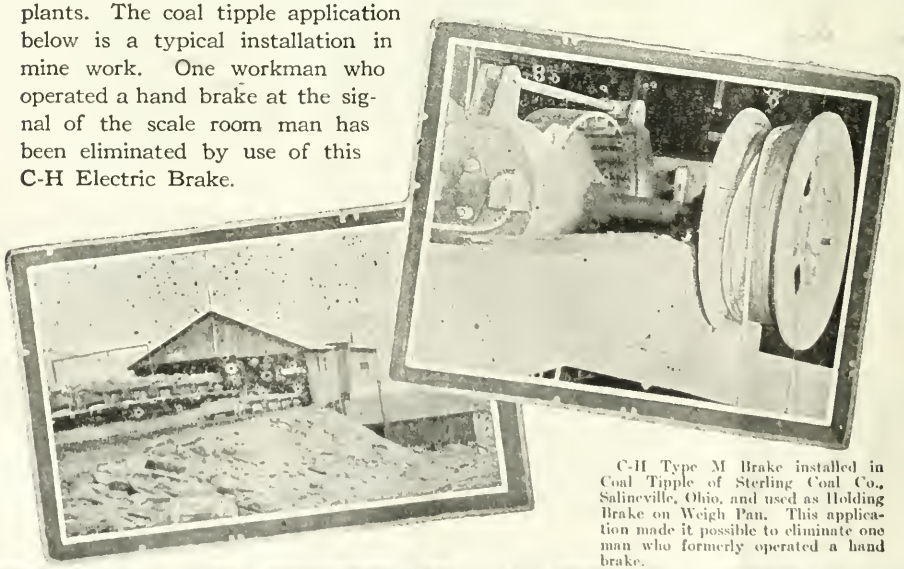


The Latest Design of C-H Type M Brake

Hundreds are being used in all kinds of hoists, cranes, and elevators —in mines, steel mills, and other industrial plants.

The small amount of space required, and the ease of adjustment make them the choice as standard in hundreds of plants. The coal tipple application below is a typical installation in mine work. One workman who operated a hand brake at the signal of the scale room man has been eliminated by use of this C-H Electric Brake.

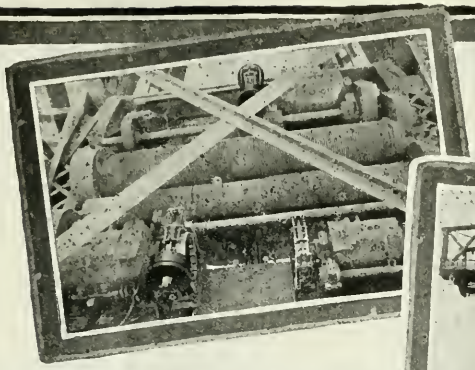
The overall height is only a trifle over the brake wheel since the latest design has the magnet armature built as an integral part of the arms carrying the brake shoes. Capacities from 1 to 300 H. P. are made in sizes from 8-inch to 30-inch.



C-H Type M Brake installed in Coal Tipple of Sterling Coal Co., Salineville, Ohio, and used as Holding Brake on Weigh Pan. This application made it possible to eliminate one man who formerly operated a hand brake.

CUTLER-

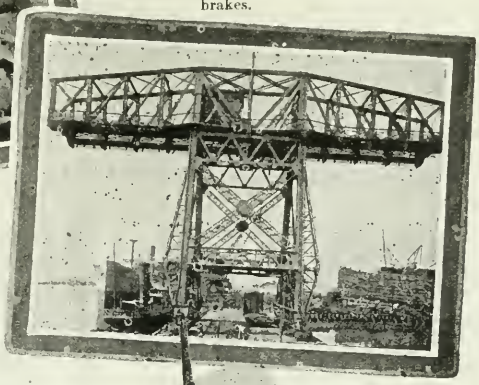
Co-operate:—Refer to The Blast Furnace and Steel Plant



The boom motor is 35 H. P. with a 14-inch brake. The winding drum motor is equipped with a second brake, and the third is a modified type operated by a lever from the crane cab and is used with a 5 H. P. motor operating the "swing."

C-H

The 150,000 pound gantry crane at the Newark Shipyard has all its motors equipped with C-H type of brakes.



156 On One Boom Hoist Job

All the motors on the huge 75-ton gantry crane at the Newark Bay shipyard of the Submarine Boat Corporation, are equipped with C-H Type M Brakes. On every one of the 56 Boom hoists on the 28 shipways of this yard there are three C-H Brakes of this type.

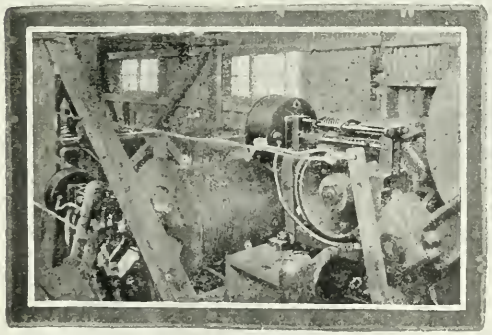
New Booklet

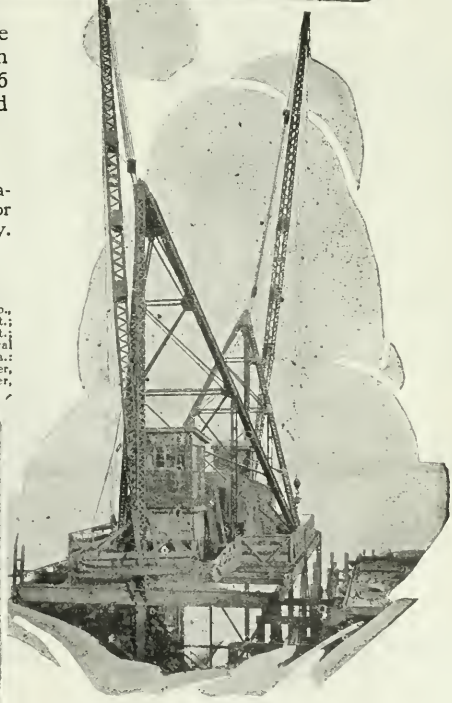
Publication 850, giving complete description, illustrations, methods of application and other data, is ready for distribution. Any district office will send you a copy.

THE CUTLER-HAMMER MFG. CO.
WORKS: MILWAUKEE AND NEW YORK

District Offices: New York: Hudson Terminal Bldg. (50 Church St.); Chicago: 323 No. Michigan Ave.; Pittsburgh: Farmers' Bank Bldg.; Boston: 77 Franklin St.; Philadelphia: Commonwealth Bldg.; Cleveland: Guardian Bldg.; Cincinnati: Gwynne Bldg.; Detroit: 905 Kresge Bldg.

Selling Agents: H. B. Squires Co., San Francisco: 583 Howard St.; Los Angeles: 206 So. San Pedro St.; Seattle: 552 First Ave. So.; General Machinery Co., Birmingham, Ala.: Brown-Marx Bldg.; H. L. Vaughan, Denver, 1710 Glenarm St.; L. Braudenburger, Salt Lake City, 59 West Broadway.





At the Newark shipyard of the Submarine Boat Corporation all of the 56 Boom Hoists on the 28 shipways are equipped with C-H Brakes—168 in all. These are used with the boom, winding drum and swing motors.

HAMMER

Co-operate:—Refer to The Blast Furnace and Steel Plant

Save All The Coal You Can

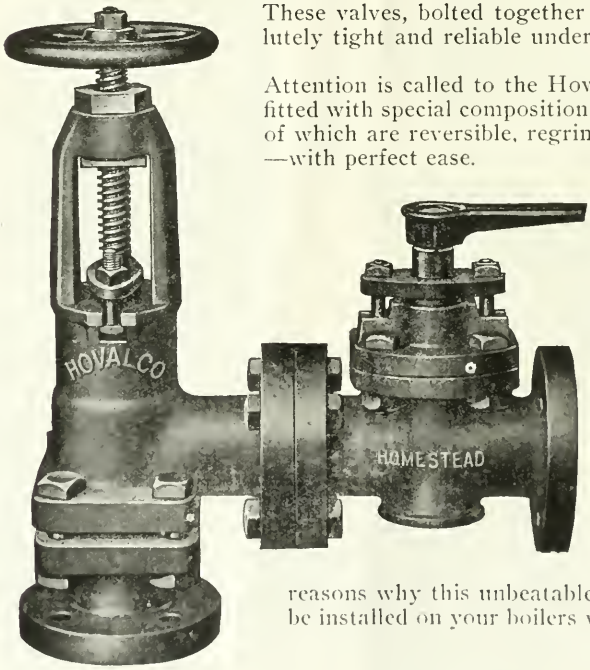
With autumn but few weeks away, you will need every extra ton of coal that you can save by eliminating the preventable sources of heat waste.

Begin at the blow-offs of your boilers. Permanently stop that continuous dribble and seepage that accumulates into a very material heat loss each month. Hundreds of dollars in good coal may easily be lost in this way in an average size plant.

Make your boiler blow-offs positively tight by equipping them all with

HOVALCO-HOMESTEAD

Combination Blow-Off Valves



These valves, bolted together as shown, are absolutely tight and reliable under the hardest service.

Attention is called to the Hovalco Valve, which is fitted with special composition seats and discs, both of which are reversible, regrindable and renewable —with perfect ease.

By closing the Homestead Valve, the Hovalco may be taken apart, inspected, repaired and reassembled without cutting the boiler out of service.

The large area opening eliminates all danger of clogging with scale.

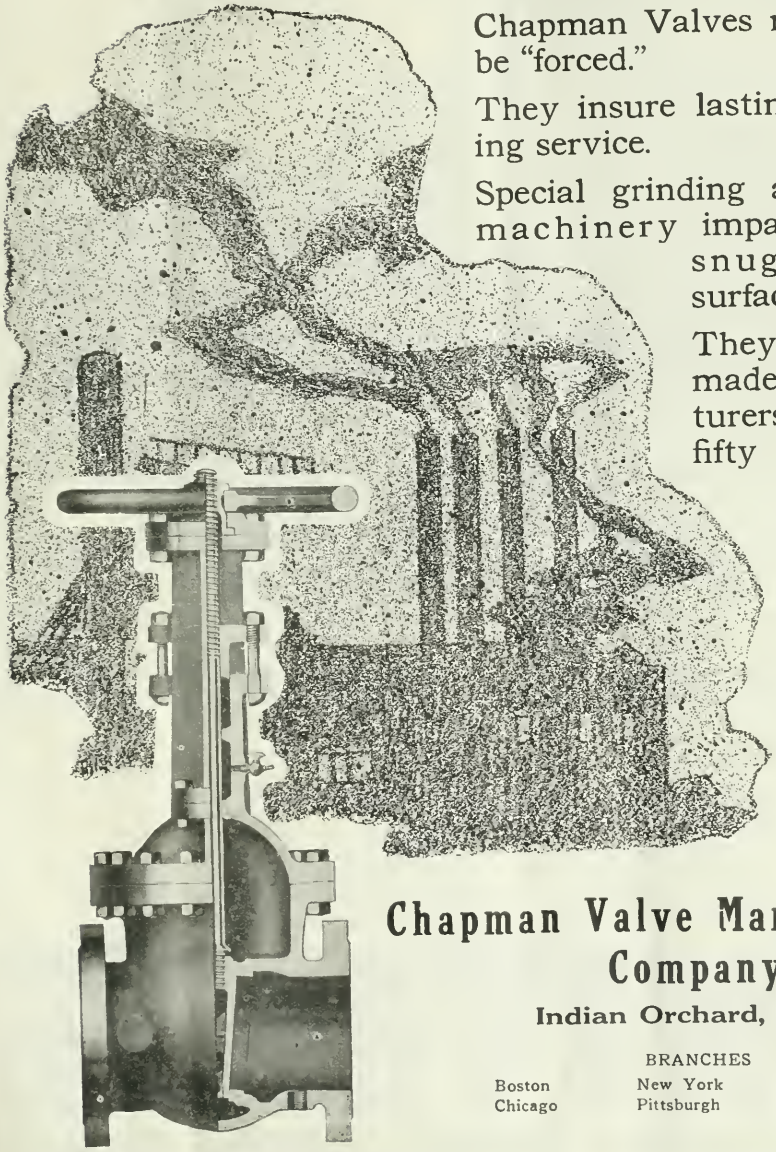
Let us give you full details and other reasons why this unbeatable combination should be installed on your boilers without delay.

Homestead Valve Mfg. Co.

134 6th Ave., Homestead, Pa. **242 Lafayette St., New York**

Chapman Valves

Exacting Service



They are built to fit the individual job for which they are intended.

Chapman Valves never need to be "forced."

They insure lasting and exacting service.

Special grinding and polishing machinery imparts a perfect, snug-fitting disc surface.

They are honestly made by manufacturers who for over fifty years have built Valves which are

Trustworthy

under all conditions.

Our 338 page Handbook on Valves No. 38 should be on your desk.

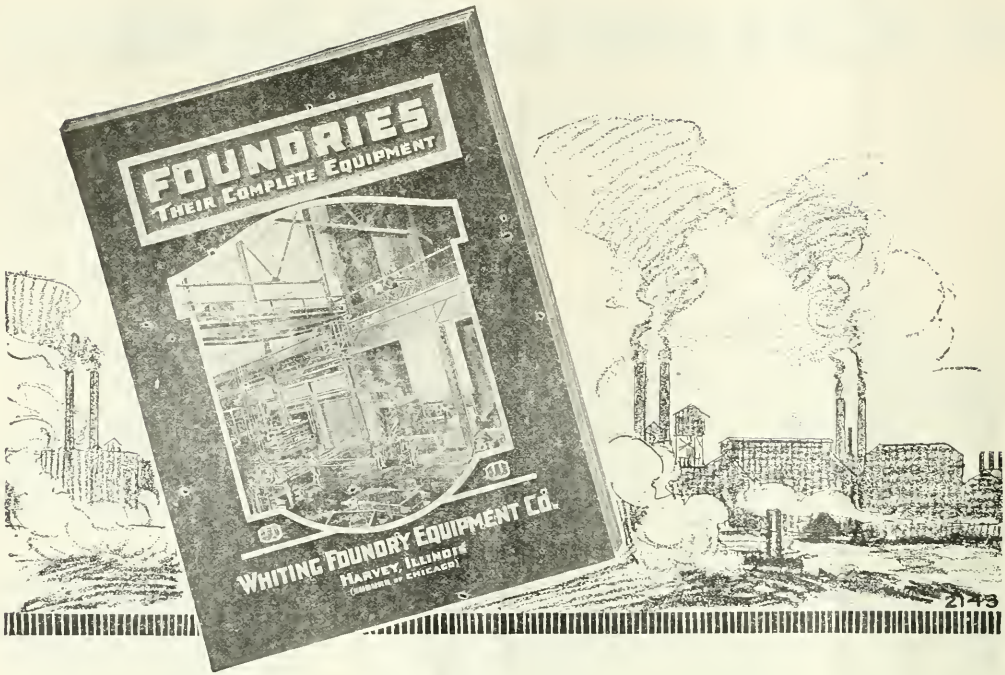
Send for it.

Chapman Valve Manufacturing Company

Indian Orchard, Mass.

BRANCHES

Boston, New York, Philadelphia, Chicago, Pittsburgh, San Francisco



Is Your Foundry Properly Laid Out and Equipped

to secure full production with a minimum of manual labor and without unnecessary handling of materials?

Our new book entitled "Foundries: Their Complete Equipment" treats of the correct layout and equipment of complete foundries for producing Grey Iron, Car Wheel, Malleable Iron, Converter Steel and Brass Castings.

It should be in the hands of anyone interested in reducing costs, contemplating the purchase of new equipment or the installation of a complete foundry.

A copy is yours on request.

WHITING CORPORATION

Consolidating:

Whiting Foundry Equipment Co. — American Foundry Equipment Co.
Sand Mixing Machine Co. — Rich Foundry Equipment Co.
Brown Specialty Machinery Co. — Buch Foundry Equipment Co.

Main Office and Works.....Harvey (Chicago Suburb) Illinois
Eastern Sales Office.....366 Madison Avenue, New York City

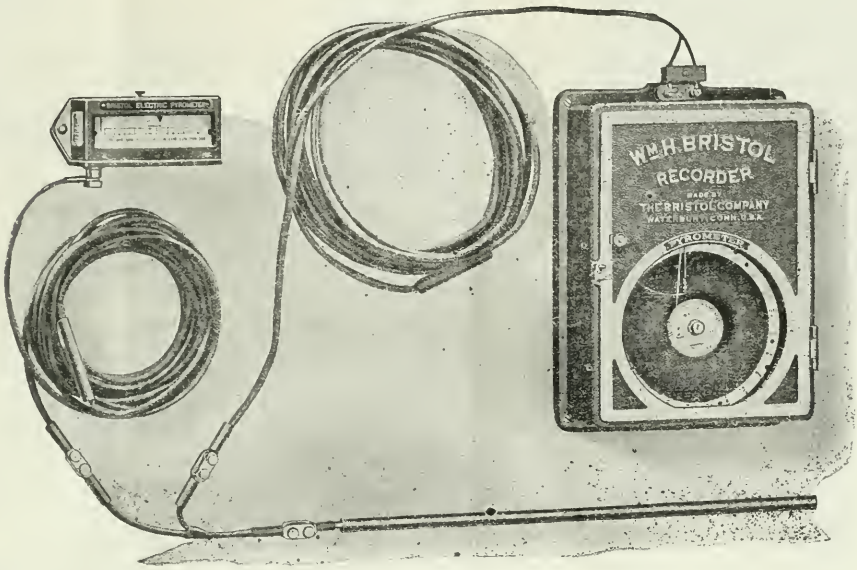
WHITING

CRANES OF ALL TYPES / FOUNDRIES EQUIPPED COMPLETE

Co-operate:—Refer to The Blast Furnace and Steel Plant

TRADE MARK
BRISTOL'S
REG. U. S. PAT. OFFICE.

The Simplest



Pyrometer Equipment

Here is a standard combination of Bristol's Indicating and Recording Pyrometer, with leads direct to the fire-end.

Note the absence of any complicated apparatus to secure constant cold-end. This is because of the Patented Automatic Internal Compensator which automatically corrects for any cold-end changes.

You who are familiar with Pyrometer apparatus will appreciate this advantage.

(1) Fire-End. (2) Lead. (3) Instrument—these simple units constitute the complete equipment.

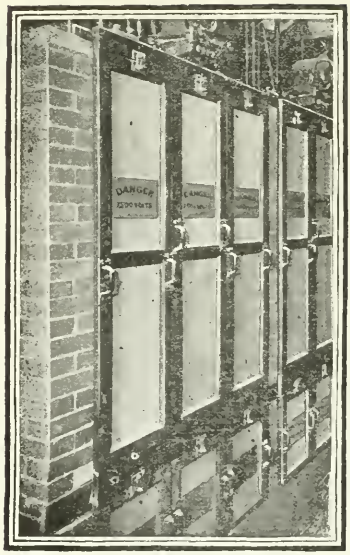
Get copy of interesting new Bulletin AD-291.

THE BRISTOL COMPANY, Waterbury, Conn.

Branch Offices:

Boston New York Pittsburgh Detroit Chicago San Francisco

Co-operate:—Refer to The Blast Furnace and Steel Plant



The signs can only warn but the barriers protect

ELECTRICAL barriers are used increasingly in station construction—a physical protection against thoughtless or accidental contact with electrical apparatus is far superior to any number of warning signs. And the necessity for barriers which can create no hazard through deterioration or structural weakness makes Johns-Manville Transite Asbestos Wood most desirable for this purpose.

For Transite Asbestos Wood is a material of great physical strength, positively fireproof, not liable to warp or crack and is light and easily worked.

Even though you have signs to warn, you need barriers of Transite to protect.

JOHNS-MANVILLE
INCORPORATED
Madison Ave. at 41st St., New York City
10 Factories—Branches in 61 Large Cities
For Canada:
CANADIAN JOHNS-MANVILLE CO., Ltd.
Toronto

JOHNS-MANVILLE SERVICE COVERS THE CONTINENT

Through—

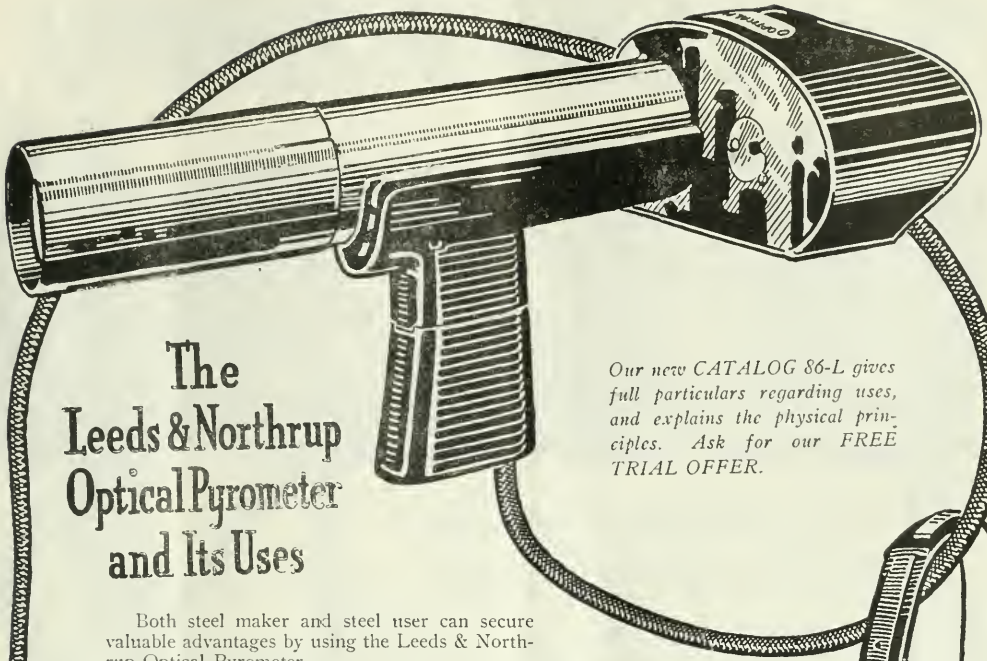
Asbestos

and its allied products

JOHNS-MANVILLE
Serves in Conservation

Heat Insulations, High Temperature Cements, Asbestos Roofings, Packings, Brake Linings, Fire Prevention Products

JOHNS-MANVILLE ELECTRICAL MATERIALS



The Leeds & Northrup Optical Pyrometer and Its Uses

Our new CATALOG 86-L gives full particulars regarding uses, and explains the physical principles. Ask for our FREE TRIAL OFFER.

Both steel maker and steel user can secure valuable advantages by using the Leeds & Northrup Optical Pyrometer.

It measures the temperature of a particular spot, which need be large enough only to serve as a background for the tungsten filament.

For example, the L. & N. Optical Pyrometer can be used for CALIBRATING THERMOCOUPLE PYROMETERS in service, by sighting upon the ends of the thermocouple protection tubes.

In the HEAT TREATMENT of HIGH SPEED STEEL, it is aimed at the tool being heated, and the latter is withdrawn as soon as it reaches the proper temperature.

In forge shops and rolling mills, the temperatures of pieces in REHEATING FURNACES are accurately determined.

In FORGING, the optical pyrometer tells when to stop because of cooling of the steel.

In the ROLLING MILL, the temperature is taken as the steel leaves the first and succeeding passes.

Furnace tapping and ingot teeming temperatures of steel have been taken successfully in connection with BESSEMER FURNACES, OPEN HEARTH FURNACES and ELECTRIC FURNACES. SLAG TEMPERATURES are likewise ascertained.

In the OPEN HEARTH FURNACE, the optical pyrometer is useful in so regulating the heat as to prevent overheating of the furnace walls and roof.

LEEDS & NORTHRUP CO.

Pyrometers *Hump Electric Furnaces*

4901 Stenton Ave. PHILADELPHIA

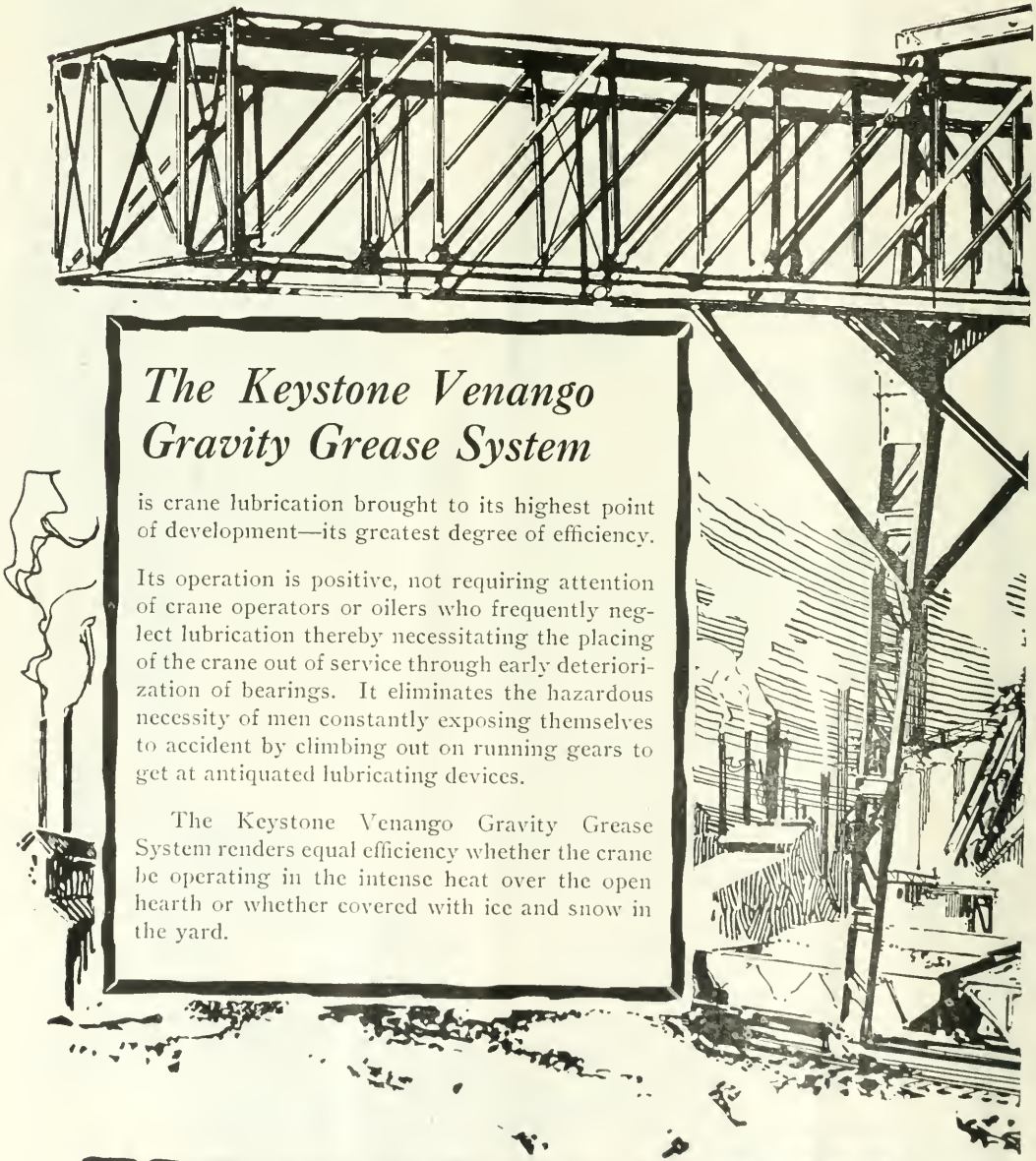
1304 Monadnock Block CHICAGO

65

Ask for our **FREE TRIAL OFFER**

Co-operate:—Refer to The Blast Furnace and Steel Plant

For LUBRICATING



The Keystone Venango Gravity Grease System

is crane lubrication brought to its highest point of development—its greatest degree of efficiency.

Its operation is positive, not requiring attention of crane operators or oilers who frequently neglect lubrication thereby necessitating the placing of the crane out of service through early deterioration of bearings. It eliminates the hazardous necessity of men constantly exposing themselves to accident by climbing out on running gears to get at antiquated lubricating devices.

The Keystone Venango Gravity Grease System renders equal efficiency whether the crane be operating in the intense heat over the open hearth or whether covered with ice and snow in the yard.

KEYSTONE

Co-operate:—Refer to The Blast Furnace and Steel Plant

CRANES *and* ORE BRIDGES

Many of the Largest Cranes in the World

are now equipped with the Keystone Venango Gravity Grease System.

Bethlehem Steel Company, South Bethlehem, Pa.
American Bridge Company, Philadelphia, Pa.
Pressed Steel Car Company, Pittsburgh, Pa.
American Sheet & Tin Plate Company, Vandergrift, Pa.
Carnegie Steel Company, Pittsburgh, Pa.
Cambria Steel Company, Johnstown, Pa.
Youngstown Iron & Steel Company, Youngstown, O.
Trumbull Steel Company, Warren, O.
Erie City Iron Company, Erie, Pa.
Carbon Steel Company, Pittsburgh, Pa.
McKeesport Sheet & Tin Plate Company, McKeesport, Pa.
United Engineering & Foundry Company, Vandergrift, Pa.
Logan Iron & Steel Company, Burnham, Pa.
Bethlehem Steel Company, Steelton, Pa.
Central Iron & Steel Company, Harrisburg, Pa.
McClintic-Marshall Construction Company, Rankin, Pa.
Bethlehem Steel Company, Sparrows Pt., Md.
McClintic-Marshall Construction Company, Pottstown, Pa.
Schoen Car Wheel Works, of Carnegie Steel Company, McKees Rocks, Pa.
Hubbard Steel Foundries, East Chicago, Ind.

We guarantee the Keystone Venango Gravity Grease System to give entire satisfaction and will, at your request, send one of our mechanical engineers to go through your plant and arrange for an installation at our risk.

KEYSTONE LUBRICATING CO.

Chicago
New York
Boston
Pittsburgh

Executive Office and Works
PHILADELPHIA, PA.
Established 1884

Denver
Minneapolis
Houston
St. Louis
San Francisco

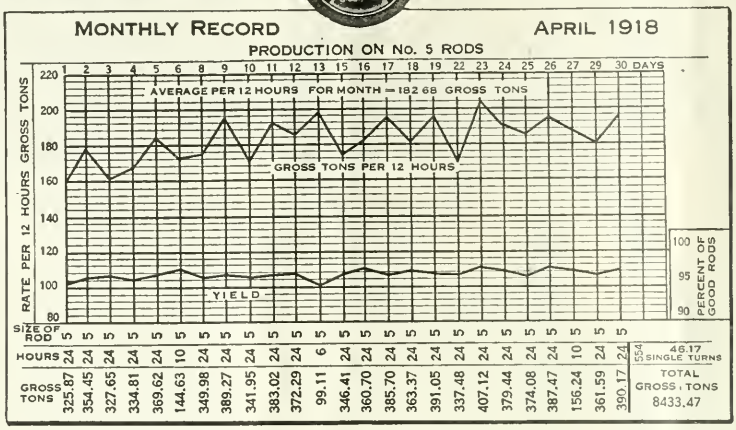
Continental European Office, Marseilles, France

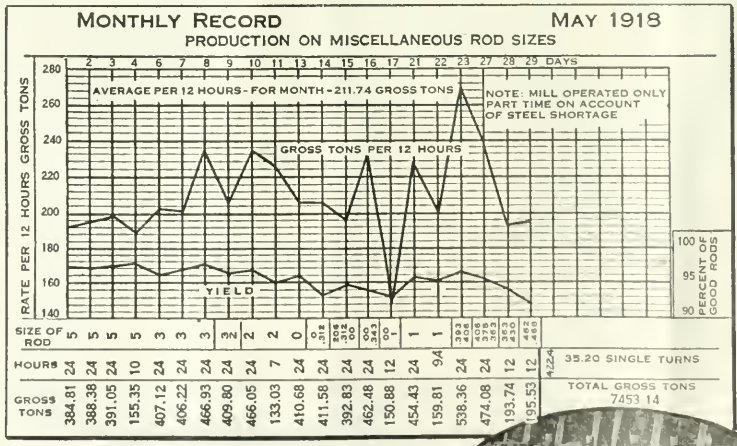
GREASE

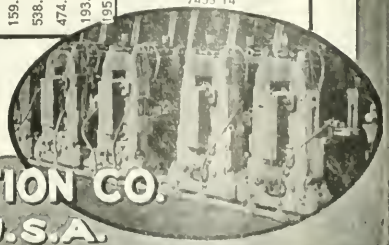
Co-operate:—Refer to The Blast Furnace and Steel Plant

MORGAN
OF WORCESTER
CONTINUOUS DOUBLE STRAND ROD MILLS

M C CO.




MONTHLY RECORD
MAY 1918
PRODUCTION ON MISCELLANEOUS ROD SIZES
AVERAGE PER 12 HOURS - FOR MONTH - 211.74 GROSS TONS
NOTE: MILL OPERATED ONLY PART TIME ON ACCOUNT OF STEEL SHORTAGE
GROSS TONS PER 12 HOURS
YIELD
RATE PER 12 HOURS GROSS TONS
PERCENT OF GOOD RODS
SIZE OF ROD
HOURS
GROSS TONS
35.20 SINGLE TURNS
TOTAL GROSS TONS
7453.14

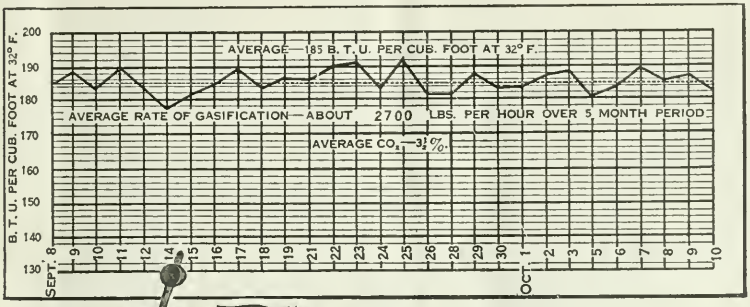


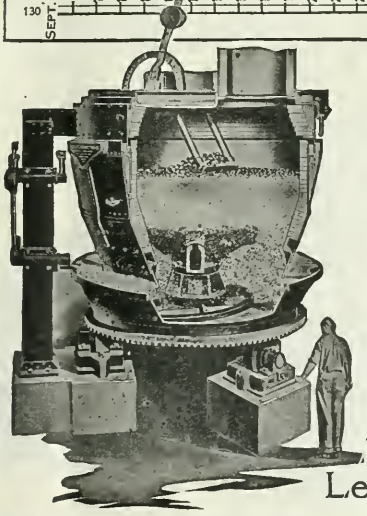
MORGAN CONSTRUCTION CO.
WORCESTER, MASS., U.S.A.

MORGAN
OF WORCESTER
PRODUCER GAS MACHINE

M C Co

Eight-hour Continuous Gas Samples from records of work's chemist at one of the well known Steel Plants in the U.S.A.


B. T. U. PER CUB. FOOT AT 32° F.
200
190
180
170
160
150
140
130
AVERAGE—185 B. T. U. PER CUB. FOOT AT 32° F.
AVERAGE RATE OF GASIFICATION—ABOUT 2700 LBS. PER HOUR OVER 5 MONTH PERIOD
AVERAGE CO_2—3½%
SEPT. 8 9 10 11 12 14 15 16 17 18 19 21 22 23 24 25 26 28 29 30 OCT. 1 2 3 5 6 7 8 9 10



MORGAN PRODUCER GAS MACHINES maintain the quality of gas continuously at a high value · · · the operation is not dependent upon the human element ·

Continuous Mechanical Feeding, Levelling and Ash Discharge

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WORCESTER, MASS., U.S.A.

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ROLLER STRAIGHTENERS
For Merchant and Structural Mills

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All rolls can be changed in
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All roll adjustments from
. the front .

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All gears in oil tight
separate Gear Housing

Built in several sizes

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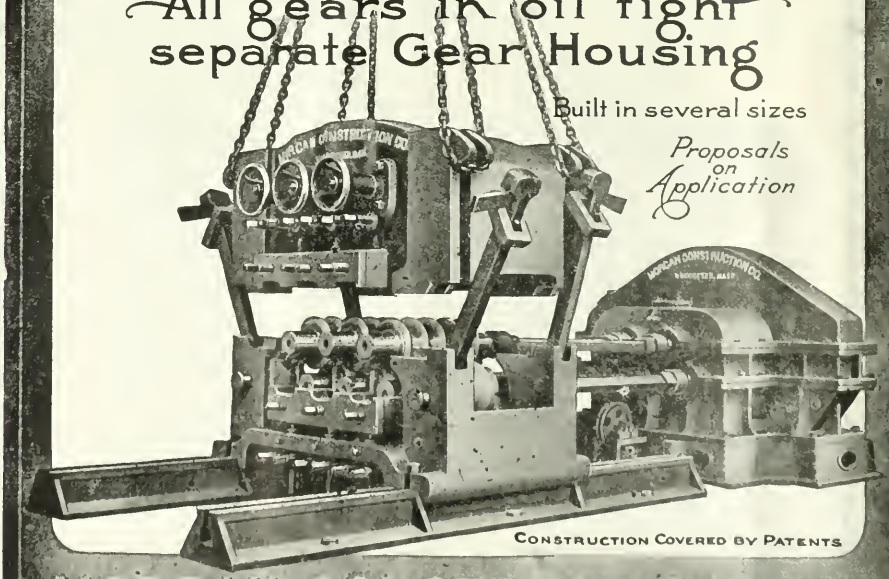

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Count the Cost!

When rising costs or curtailed orders demand sharp economy in the mill, then is the time to check up the service you are getting from men, machines and materials.

And right now, when costs count is the time to practice the most rigid economy and efficiency.

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Executive Offices, PITTSBURGH Foundries, MIDLAND, PA.

United Engineering & Foundry Co., Pittsburgh, Licensees

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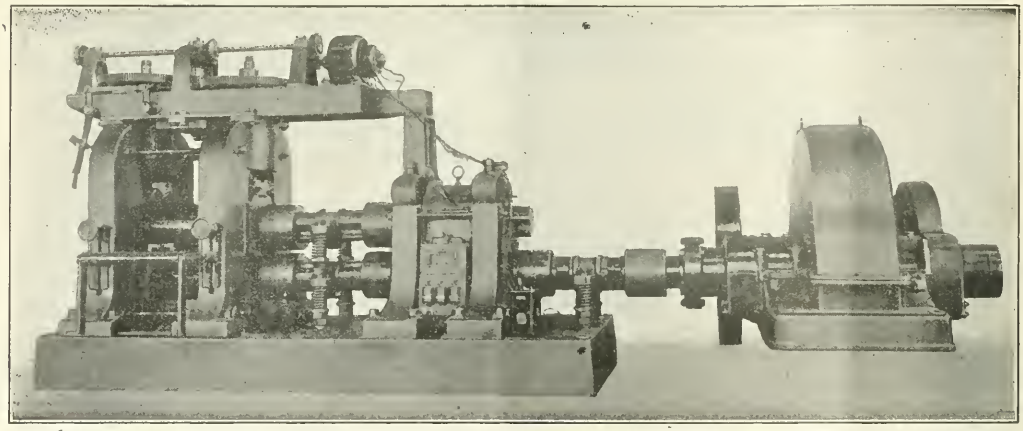

Motor Driven Strip Finishing Mill with Motor Screwdown and Cut Herringbone Gear Drive.

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Rolling Mill Machinery—All Types of Shears—Roll Lathes

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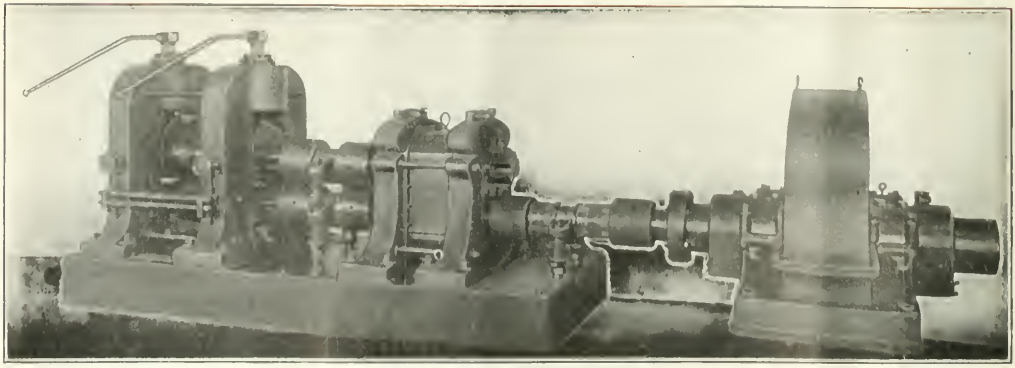
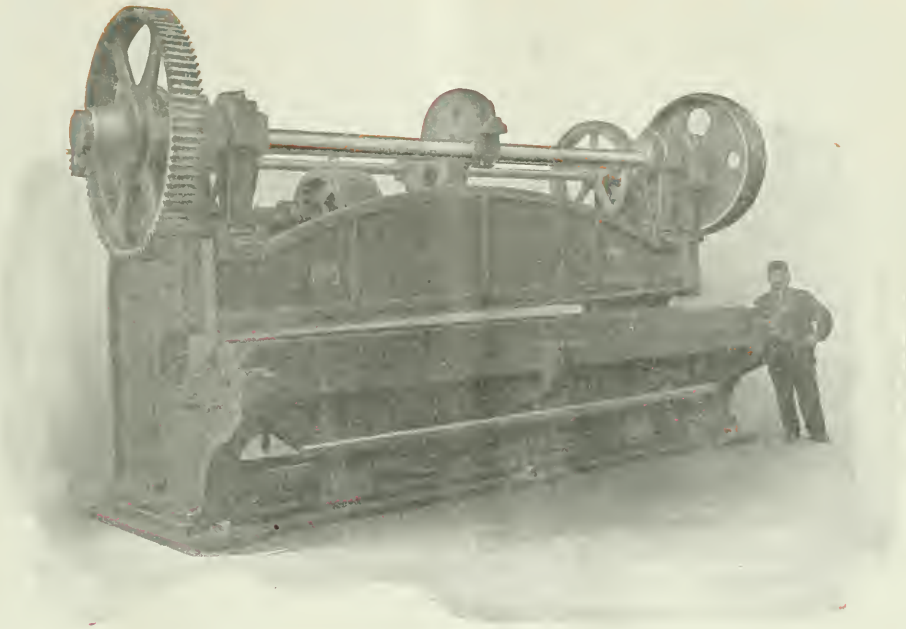


Motor Driven Strip Roughing Mill with Cut Herringbone Gear Drive.

PLATE SHEAR



Capacity 3/4" x 81" Steel, With 27" Throat, 30 H. P. Motor.

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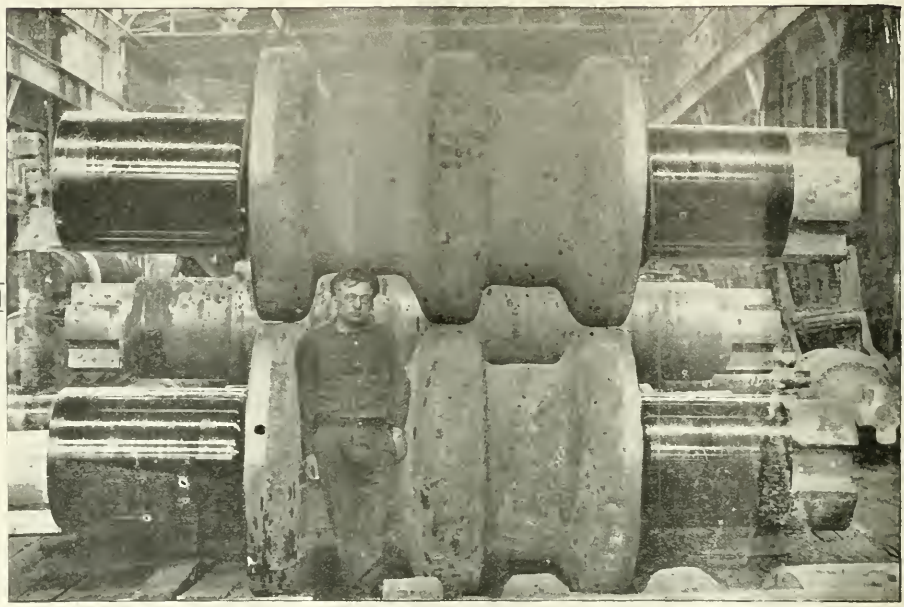
Complete Machinery Equipment for Iron, Steel, Tube, Zinc, Brass and Aluminum Works---Forging Presses, Sand and Chilled Rolls

"WHEELING QUALITY"



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SUPER-STEEL ROLLS SAND ROLLS

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Steel Castings
Special Machinery
Rolling Mill Machinery

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MOLD & FOUNDRY CO.
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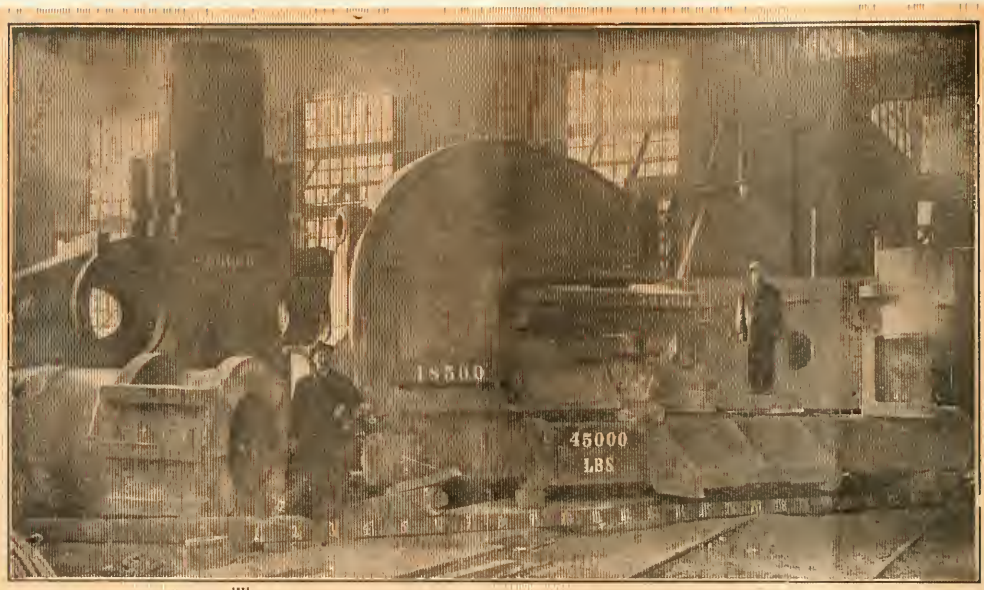
ROLLING MILL STEEL CASTINGS



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CHILLED and SAND CAST IRON ROLLS

CARBON STEEL and ALLOY STEEL ROLLS

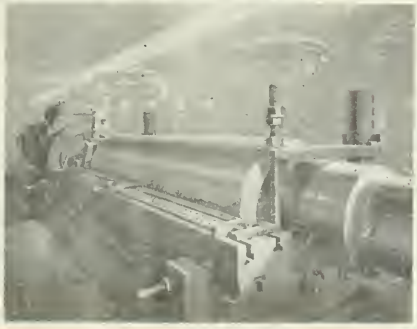
MESTA SPECIAL ROLLS

An extremely hard but strong roll of Chrome-Nickel composition, specially heat-treated.

View in Roll Turning Department equipped with 27 Lathes

View in Roll Shipping Department

View below shows 44" x 160" Chilled Roll in Finishing Lathe



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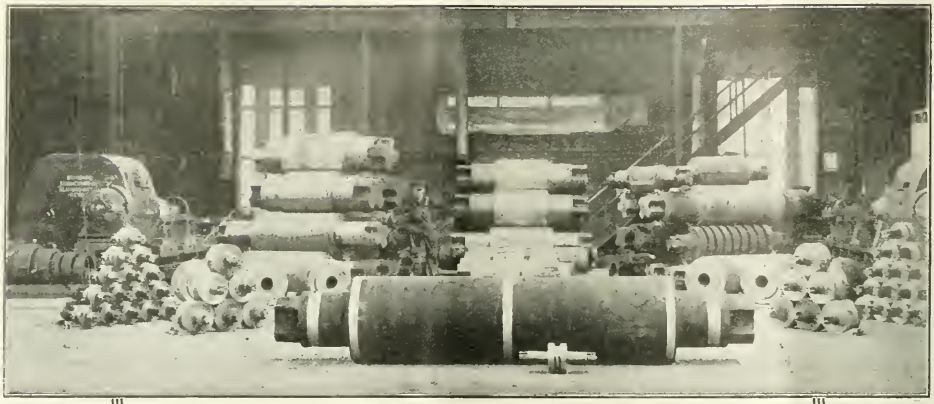

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ROLLS

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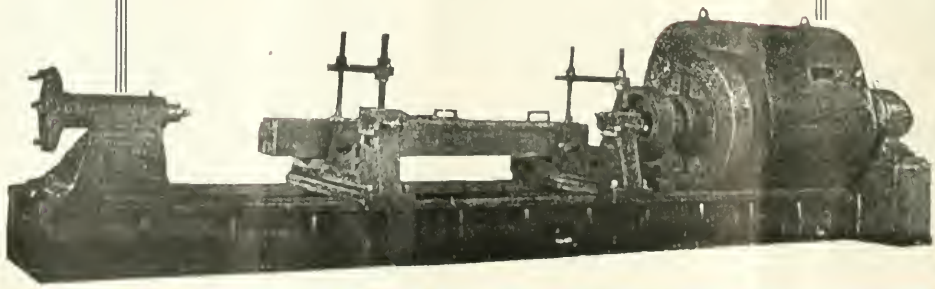

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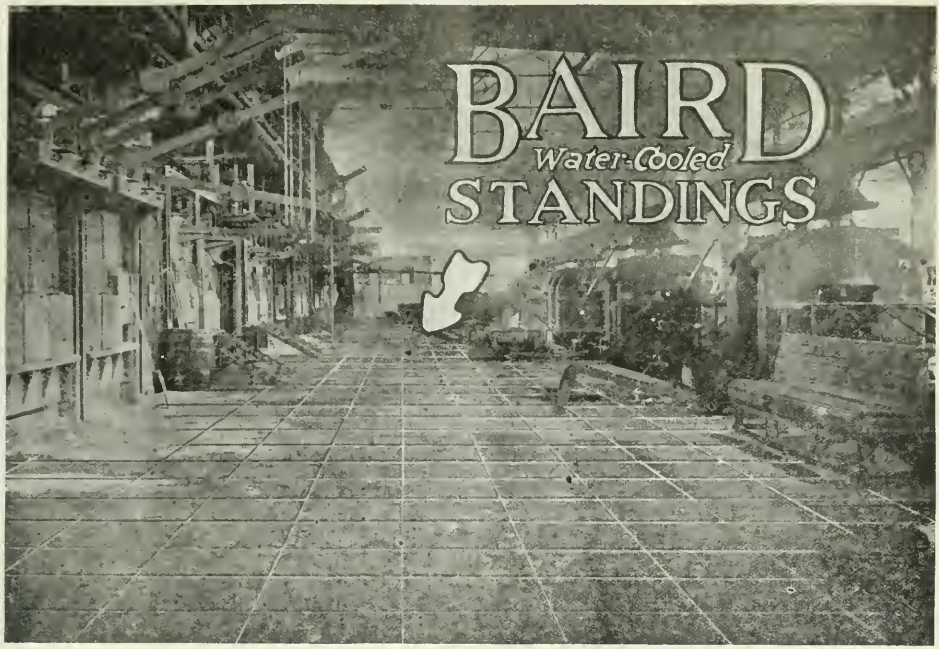

Comfort Stimulates Production

The source of the largest production will usually be traced to the operator being able to concentrate his entire attention to the production of the article in question.

Distraction and inattention naturally hinder the operator from performing his best work which, of course means a loss to the employer.

The Baird Water-Cooled Standings minimize to a large degree the heat at mill stands, therefore making the surroundings comfortable for the men whose attention is not distracted by the heat.

The success of the installations have proven their value.

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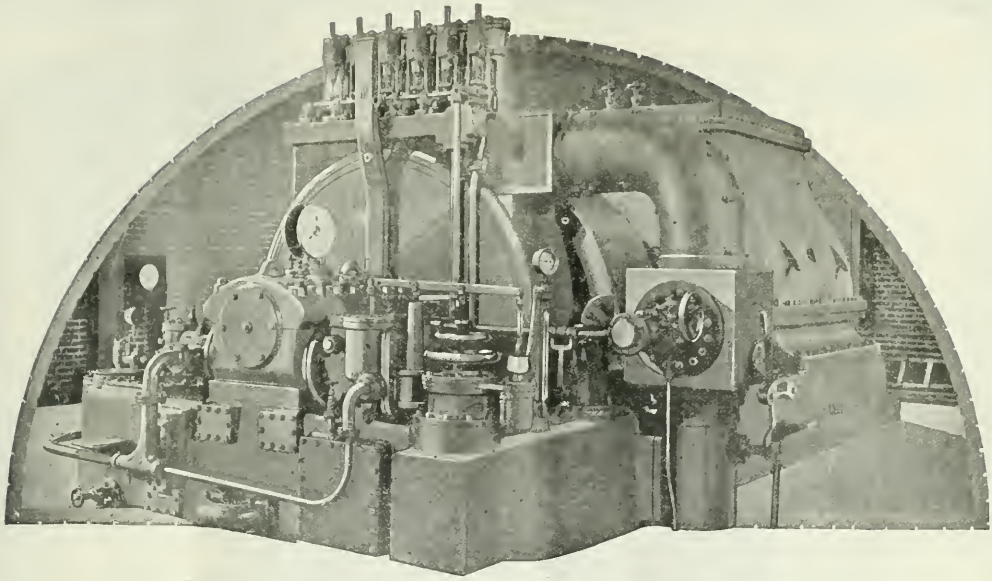

Turbo Blowers and Compressors

I-R Turbo Blowers range in capacity from 3,000 to 60,000 cubic feet per minute, and pressures from 1 pound to 30 pounds. These units are built for use with Iron Blast Furnaces, Bessemer Steel Converters, Oil Furnaces, Copper Blast Furnaces and Converters, Copper Flotation; in fact for all conditions where low pressure air or gas is required.

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General Offices: 11 Broadway, New York

Offices Everywhere.

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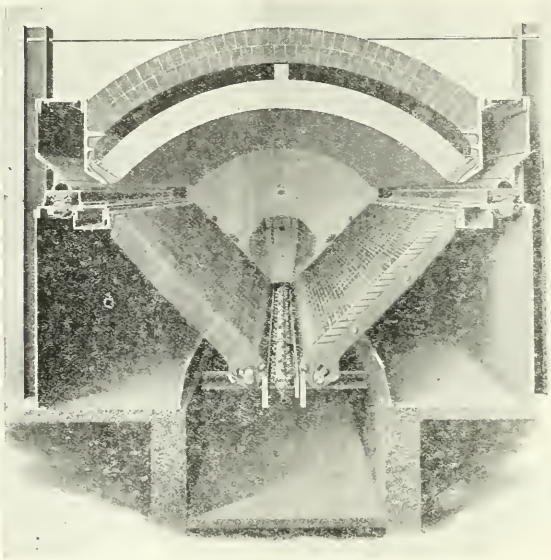

Murphy Furnaces have been relied upon by power users in every field for 44 years to furnish continuous, efficient and economical combustion service—to burn any available fuel—and to automatically remove all ash and refuse.

Factors Back of Every Installation of
MURPHY FURNACES

Natural Draft—on everything except the most extreme peak loads. Will double the output of your boilers without one penny for draft.

Burn any fuel—This is the biggest possible feature for the engineer to consider at the present time.

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MURPHY
AUTOMATIC
FURNACES

They are being used in practically every line of industry—from hospital to industrial and central station service.

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BURN ANY FUEL THAT HAS HEAT IN IT

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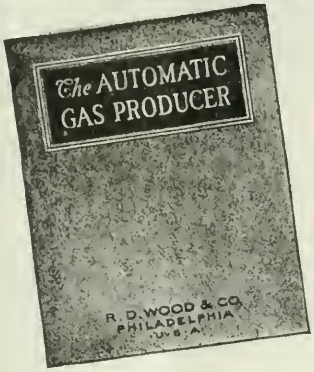
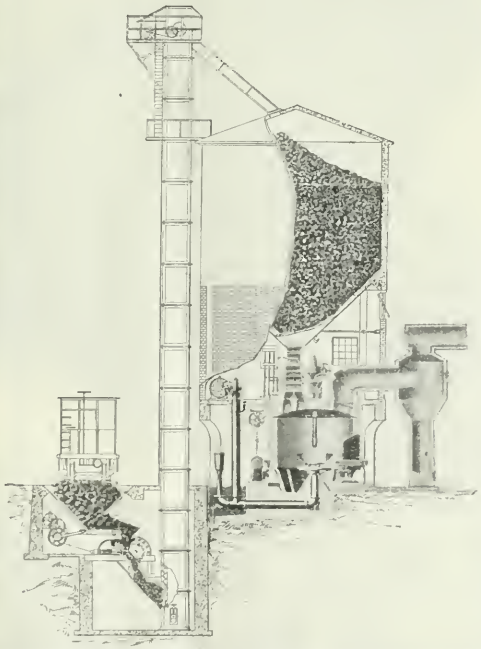


Solve Your Fuel and Labor Problem

by Equipping Your Plant with

The AUTOMATIC GAS PRODUCER



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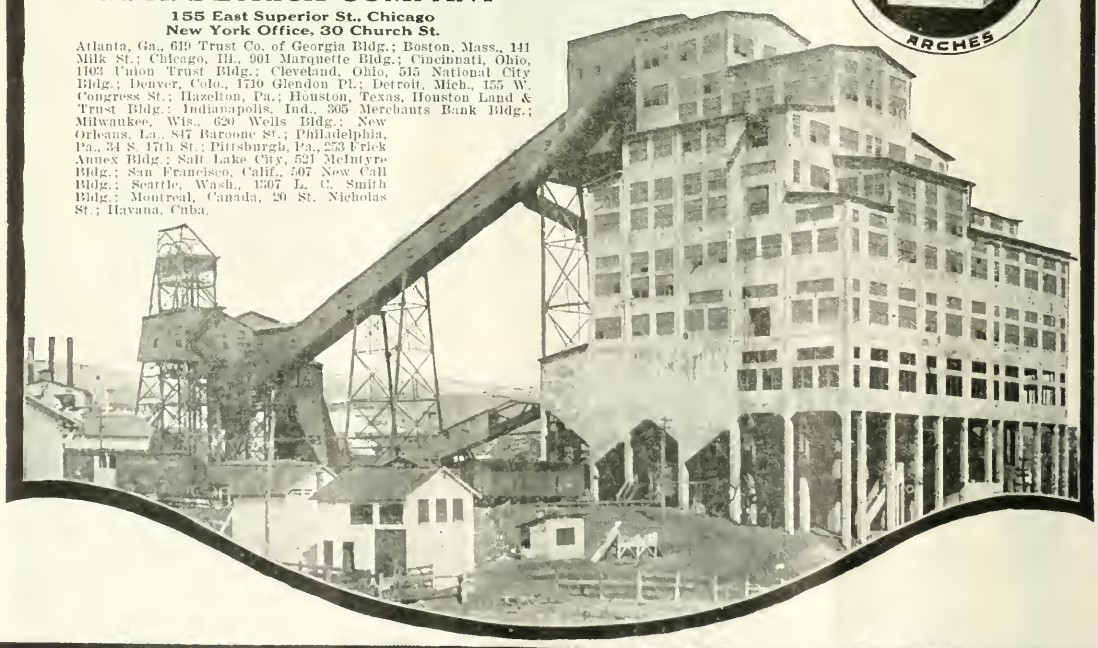
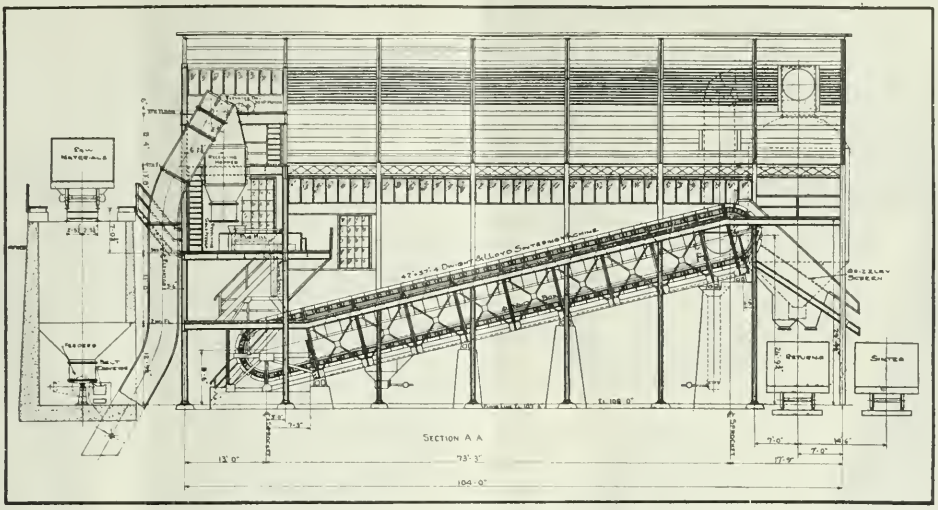


DETRICK FLAT SUSPENDED ARCHES

SINTERING PLANTS



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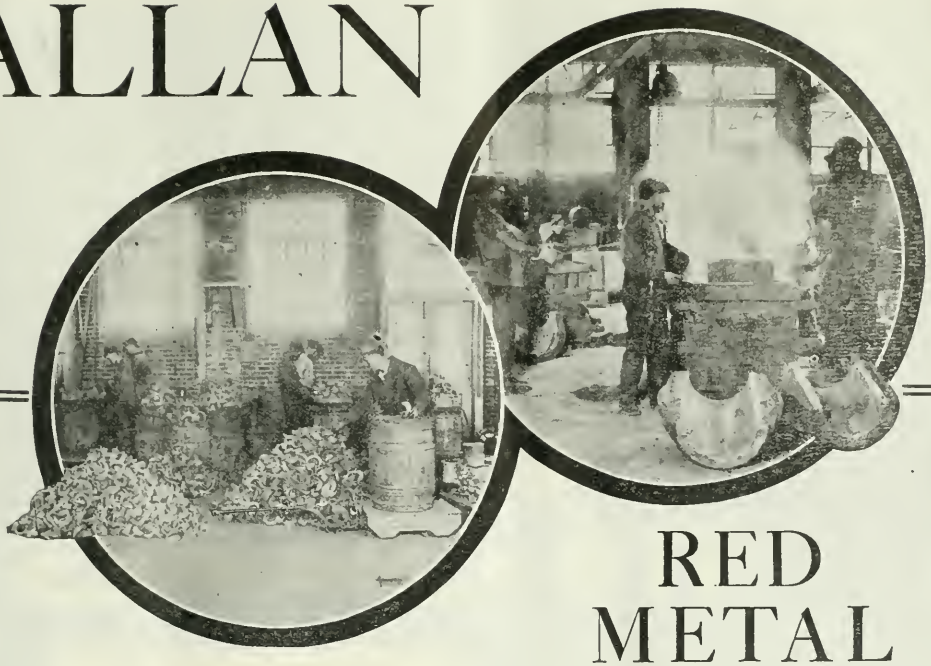

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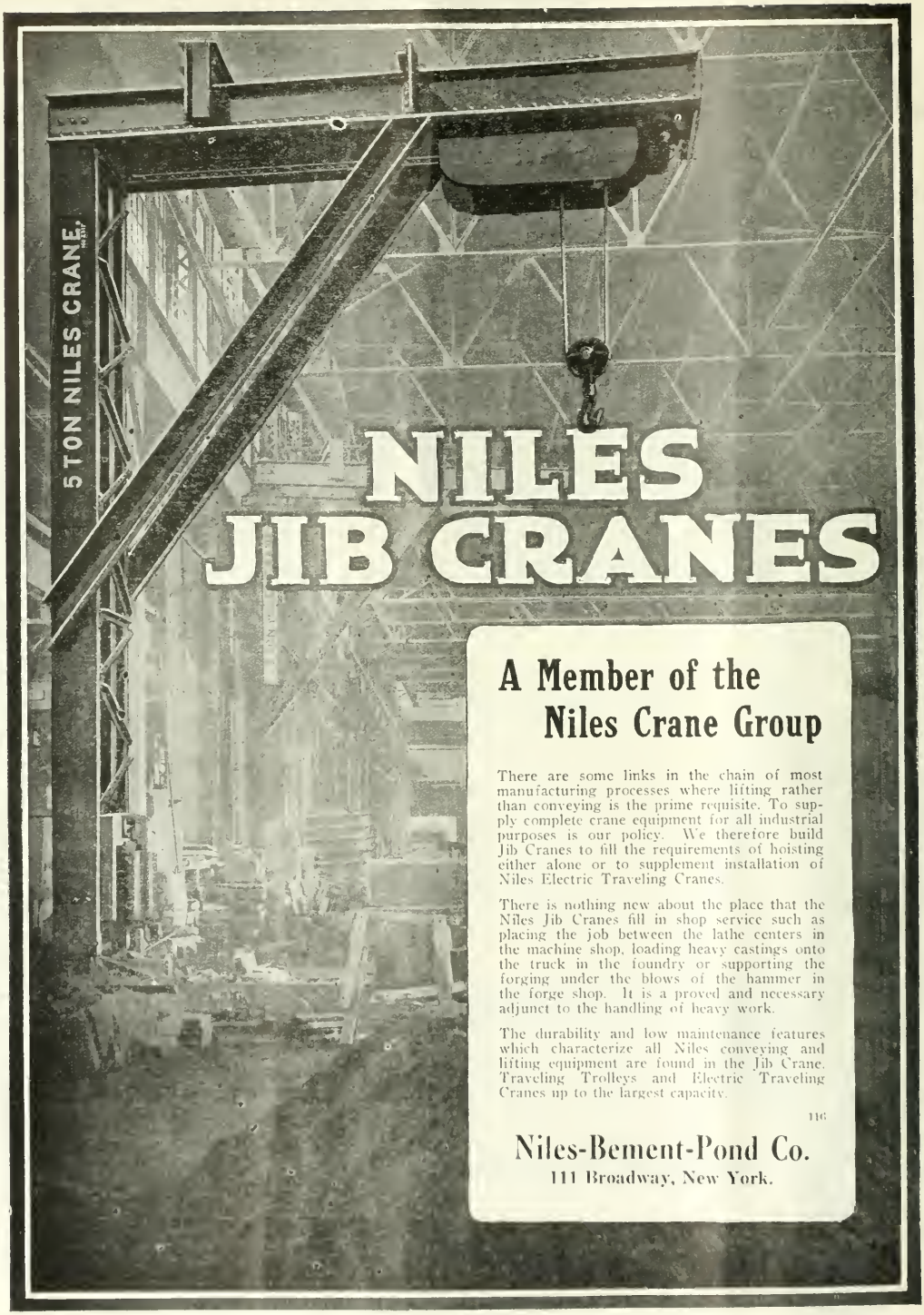
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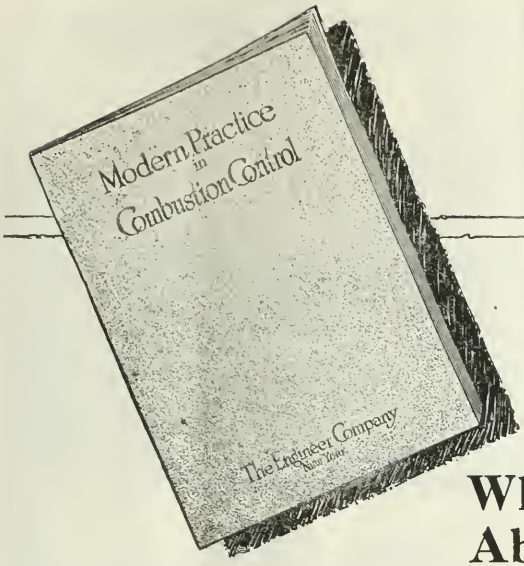

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Sharpsville, Pa.
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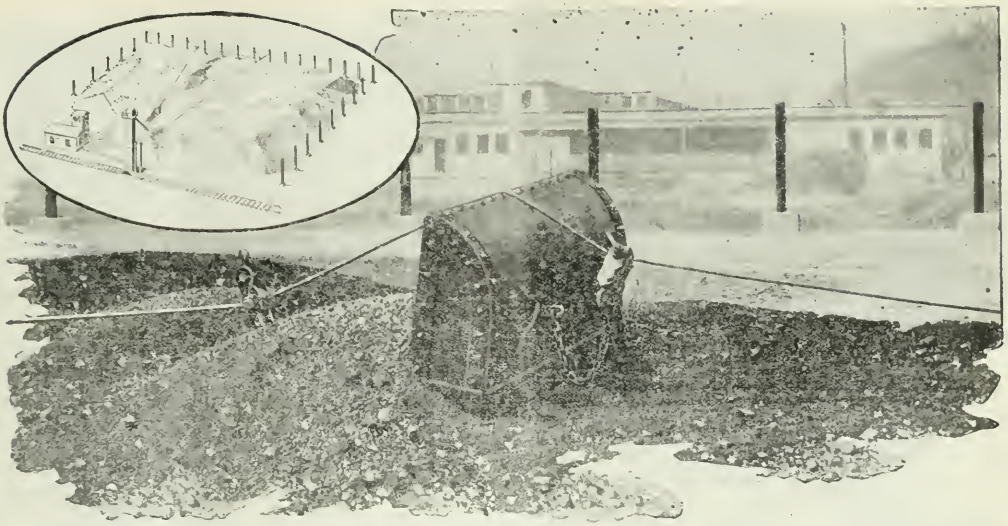

A System That Stores Coal on an Area of Any Size or Shape

Beaumont
ONE CONTRACT
ONE RESPONSIBILITY

A Few Plants Using Beaumont Equipment

Wilmington & Phila. Traction Co. Wilmington, Del.
Alfred Wolstenholme & Sons Co. Philadelphia, Pa.
Philadelphia Suburban Gas & Elec. Co. Cromby, Pa.
United States Nitrate Plant No. 1 Sheffield, Ala. (2 contracts)
Monadnock Paper Mills Bennington, N. H. (2 contracts)
National Electrolytic Company Niagara Falls, N. Y.
Baldwin Locomotive Works Philadelphia, Pa.
Michelin Tire Co. Milltown, N. J. (2 contracts)

The installation of a Beaumont Cable Drag Scraper System of coal storage does not require a large expenditure for the preparation of storage space or area. Any shaped piece of ground adjacent to your plant or railroad siding and sufficiently large to accommodate the storage pile, is all that is required. Realize how much saving in dollars and time this one feature represents.

The storage area is staked off by posts and the drag scraper cable attached as shown in the little illustration. If a larger area is required, the posts may be moved in any direction.

See how the Beaumont Cable Drag Scraper operates as illustrated in the oval above. The coal is dumped into the track hopper and elevated to a chute which piles it up. Then the drag scraper distributes it over the storage area, storing the various sizes separately if so desired. Any size coal can be handled. When the coal is needed in the boiler house the operation is reversed.

No skilled or licensed labor is needed to operate the Beaumont Cable Drag Scraper. *One* man operates the entire system. 50 to 100 tons an hour can be stored at a labor cost of less than 1 cent a ton. Should fire threaten in any section of the coal pile the drag scraper will attack it immediately. In some cases several manufacturers have combined in a co-operative coal storage plan whereby sufficient coal can be stored to insure against a possible shut down.

A reserve storage system capable of taking care of any amount of coal whenever you can get it is today the best insurance against a forced shut down.

The Beaumont book "Cable Drag Scraper Systems for Storing Coal" gives much information of value to executives. It will be sent on request.

R·H· BEAUMONT CO·

Coal and Ash Handling Systems for Boiler Houses

330 Arch Street **Philadelphia**

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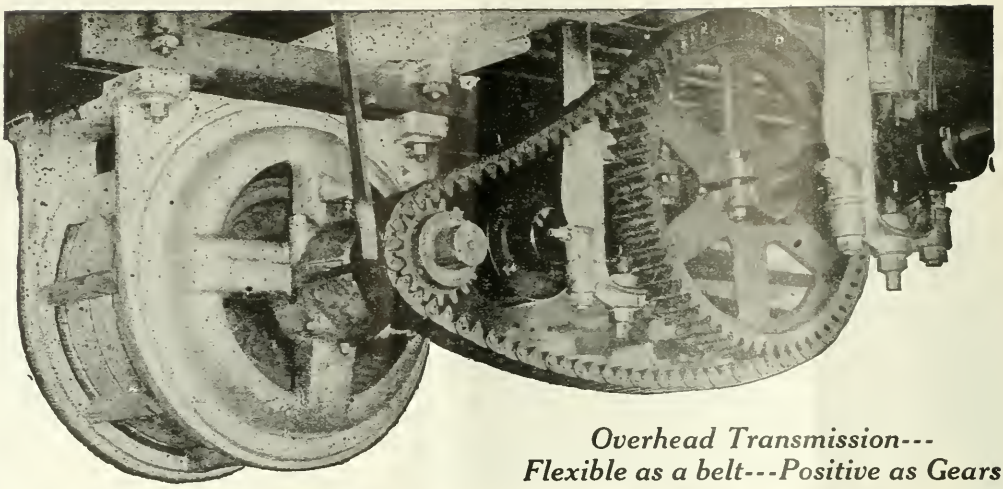

Overhead Transmission---
Flexible as a belt---Positive as Gears

MORSE SILENT ROCKER JOINT CHAIN DRIVES

and Transmission Efficiency are synonomous. For severe duty they have no peer. Overload, transmitted without slip means power conservation and increased production. When you install a Morse Drive your belting and power delivery worries are abolished, insuring continuous operation and the elimination of serious delays.

Make your next drive a Morse. The Silent Partner is an apostle of power conservation.

You need him because he averages 99% efficient.

Write us on your drive difficulty.

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Largest Manufacturers of Silent Chains in the World

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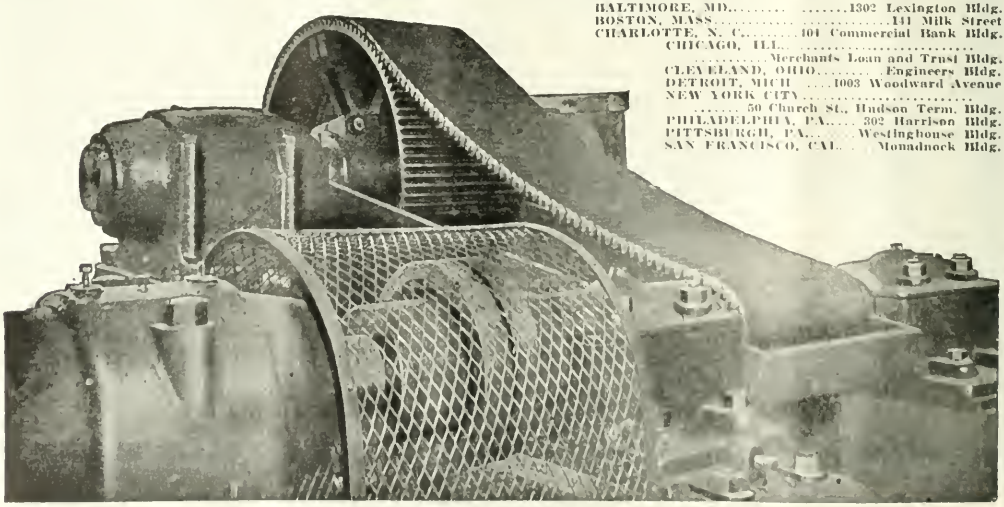
KANSAS CITY, MO.....Morse Engineering Co., Finance Bldg.
MINNEAPOLIS, MINN.....113 3rd St., Strong-Scott Mfg. Co.
ST, LOUIS, MO.....Morse Engineering Co., Chemical Bldg.

BALTIMORE, MD.....1302 Lexington Bldg.
BOSTON, MASS.....141 Milk Street
CHARLOTTE, N. C.....101 Commercial Bank Bldg.
CHICAGO, ILL.....Merchants Loan and Trust Bldg.
CLEVELAND, OHIO.....Engineers Bldg.
DETROIT, MICH.....1003 Woodward Avenue
NEW YORK CITY.....50 Church St., Hudson Term. Bldg.
PHILADELPHIA, PA.....202 Harrison Bldg.
PITTSBURGH, PA.....Westinghouse Bldg.
SAN FRANCISCO, CAL.....Monadnock Bldg.



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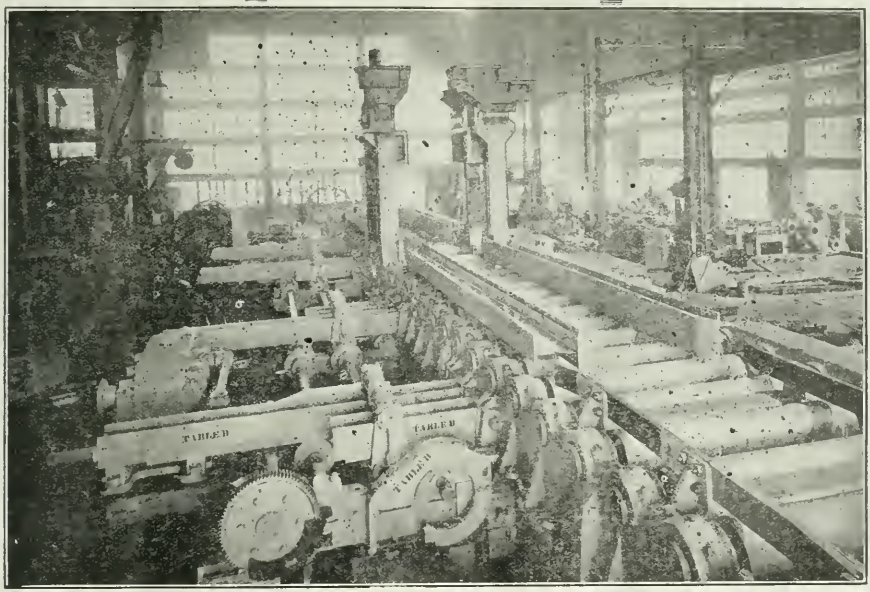
TREADWELL



34" Treadwell two-high Reversing Blooming Mill for the Automobile M. Berliet, Usines de Venissieux, Rhone, France, on our Erection floor.

MODERN ROLLING MILL MACHINERY AND STEEL MILL EQUIPMENT

TREADWELL ENGINEERING COMPANY
EASTON, PA., U.S.A.

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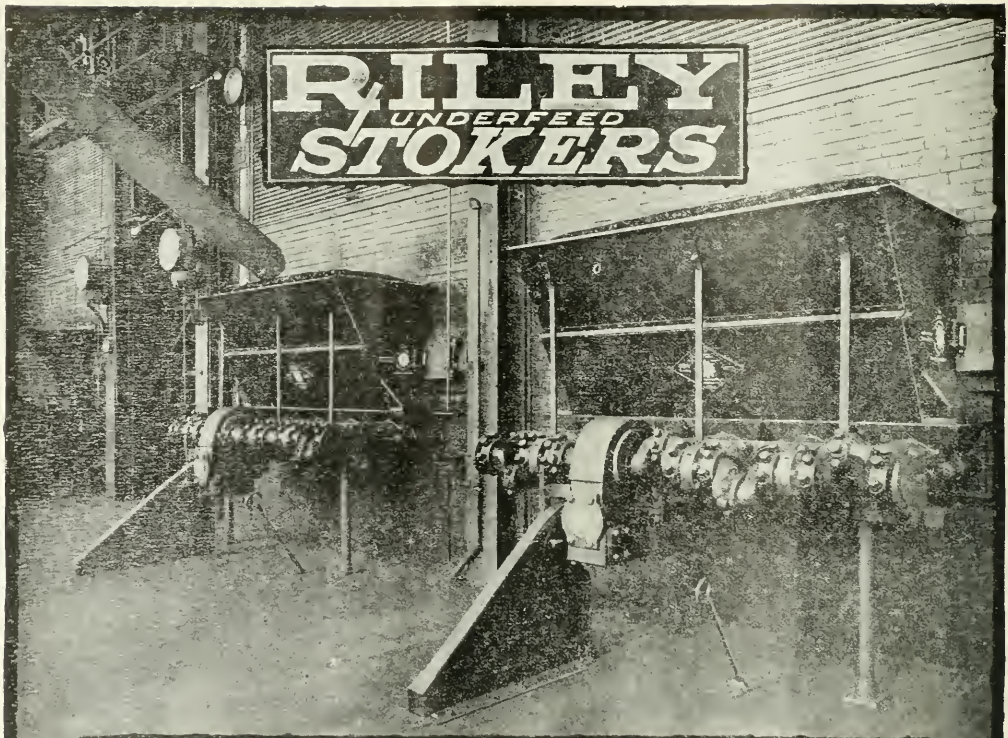

Installation of five-retort RILEY STOKERS at the Hood Rubber Co., Watertown, Mass.

Careful Comparison Proves

That an "All Riley Stokered" boiler house means efficient, reliable steam production at minimum maintenance cost.

In 1915 the Hood Rubber Company installed two five-retort Riley Stokers under 500 HP Edge Moor Boilers. Their plant is equipped with all modern appliances and they have made an accurate comparison of maintenance and operating charges, so they know the exact savings made by using Riley Stokers.

Later as steam demands grew two five-retort stokers were installed under new boilers and now two more five-retort stokers are on order to replace other stokers, making this an "All Riley Stokered" plant.

Can you ask for better evidence of the high standard of economical service given by Riley Stokers? Let us send you facts, also descriptive catalog.

Sanford Riley Stoker Co., Worcester, Mass.

Co-operation Plus

Two men working together may easily accomplish tasks that one working alone could never handle. Two brains working together, may solve problems otherwise impossible to work out separately. The power of co-operation is one of natural law.

But even co-operation flounders in the mire of experimentation without an accumulated fund of experience upon which to form intelligent conclusions, and make the result of its labors as certain as the law of gravitation.

Robert Gordon, Inc., represent specialized co-operating minds in the matter of heating and ventilating engineering. It is a matter of principle that the best interests to be served are those of the clients. Long experience with many kinds of heating installations, makes recommendations and installations possible that accurately fit *your* conditions. Thousands of successful installations give meaning to the slogan.

"Gordon—A Guarantee of Dependable Service"

Robert Gordon, Inc., service is everything implied in the word "dependable". Send now for the booklet "Warm Facts in Cold Type" which summarizes this service.

ROBERT GORDON, INC.

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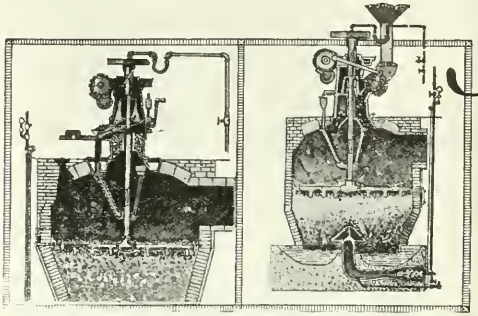
Grand Central Palace, New York; Bessemer Bldg., Pittsburgh; Sun Bldg., Detroit.
Canadian Agents: E. J. Woodison Co., Ltd., Toronto and Montreal.

What's the "Follow Through" on Chapman Gas?



Chapman automatic feed and agitator applied to any old type producer.

Chapman mechanical producer —the solution of the gas house problem.

JUST how much will you gain if you save 70% of the labor and 20% of the fuel in your gas house each day?

Chapman Agitators applied to old hand-poked producers are doing this every day in numerous plants in the steel districts.

Just how much will you gain if you save from 75 to 100% of your investment in the first year of operation?

Our customers report this average.

These are some of the reasons why 72% of our business is repeat orders.

The name Chapman has come to mean constant service to users of producer gas.

It means the ability to recommend and to furnish only such equipment as will suit your conditions.

Completely Mechanical Producers for a new installation or Floating Agitators with Automatic Coal Feed if you prefer to retain your old shells.

Then comes the Chapman "follow through" of inspection and coöperation with the constant determination to see that your plant operates at the highest efficiency.

Save your fuel, turn your gas house into a paying investment, cut the waste out of this most backward department of our greatest industry. You can begin by writing us for full technical data today.

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C&G *Division of The*
COOPER
MT. VERNON, OHIO. CO.

11 Broadway, New York — Oliver Building, Pittsburgh

Since 1833 Engineers and Builders

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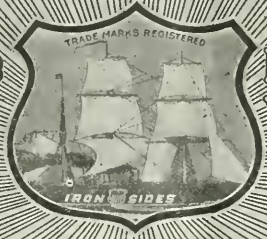
THE IRONSIDES COMPANY
COLUMBUS OHIO

Ironsides Gear Shield



Ironsides Wire Rope Shield

Ironsides Automobile Gear Shield

Lubrication Reduces the Wear—on your wire ropes and gears—means longer service—at a substantial saving.

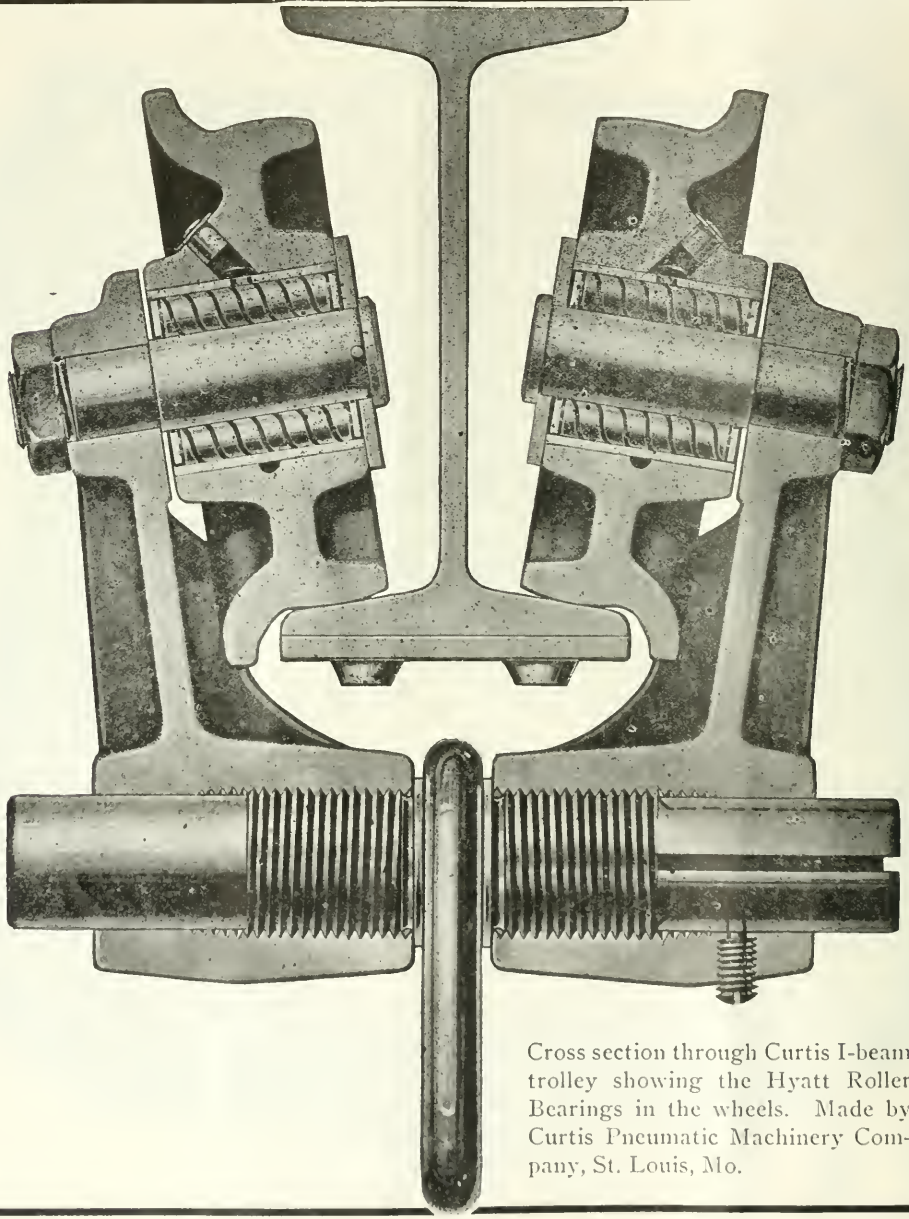
Ironsides Wire Rope Shield—for preservation and lubrication—widely used in Mines, Blast Furnaces, Steel Plants and Factories.

Ironsides Gear Shield—lessens noise, wear and costly replacements—used by up-to-date Rolling Mills.

Ironsides Cold Neck Shield—the best roll-neck lubricant in existence—for Rolling Mills.

Ironsides Cold Neck Shield

Handling of Material Made



Cross section through Curtis I-beam trolley showing the Hyatt Roller Bearings in the wheels. Made by Curtis Pneumatic Machinery Company, St. Louis, Mo.

HYATT BEARINGS FOR

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Easy by Curtis-Hyatt Trolleys

MATERIAL can be easily and quickly handled by Curtis-Hyatt Roller Bearing equipped I-beam trolleys. They cut labor costs, release labor for more productive work and keep material on the move.

Hyatt Roller Bearings are of special value on trolleys—making them easy running and insuring smooth operation. These husky bearings operate for years with no appreciable wear and require lubrication but 3 or 4 times a year.

The equipping of trolleys with Hyatt Rolle Bearings is a sure and inexpensive way to speed up the transfer of material. Besides, you get the added advantage of having modern equipment.

Curtis I-beam trolleys are made by the Curtis Pneumatic Machinery Company, St. Louis, Mo. It will pay you to specify economical, dependable, Hyatt Roller Bearing equipped Curtis I-beam trolleys on your next order.

B-730

HYATT ROLLER BEARING COMPANY
INDUSTRIAL BEARINGS DIVISION
NEW YORK, N. Y.

MOTOR BEARINGS DIVISION, DETROIT, MICH.

TRACTOR BEARINGS DIVISION, CHICAGO, ILL.

Manufacturers of Bearings for Mine Cars, Ore Cars, Steel Mill Cars, Roller Tables, Trolleys, Cranes Hoists, Machine Tools, Line Shafts, Countershafts, Concrete Machinery, Textile Machinery, Conveyors, Lift Trucks, Industrial Trucks, Railway Service, Cars, Storage Battery Locomotives, etc.

CRANES, TROLLEYS & HOISTS

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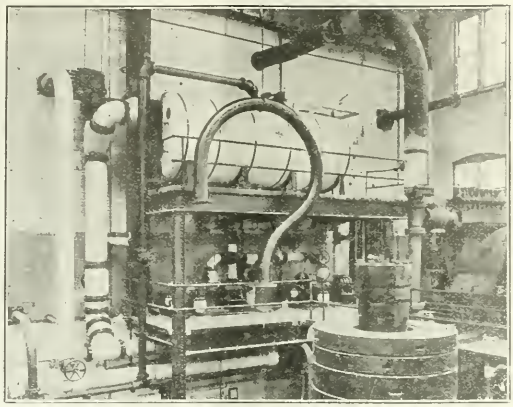

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"WHEN YOU THINK OF PIPING THINK OF PITTSBURGH PIPING."

POWER PLANT PIPING

—FOR—

ELECTRIC LIGHT, STREET RAILWAY, BLAST FURNACE, STEEL WORKS and INDUSTRIAL PLANTS of every description.

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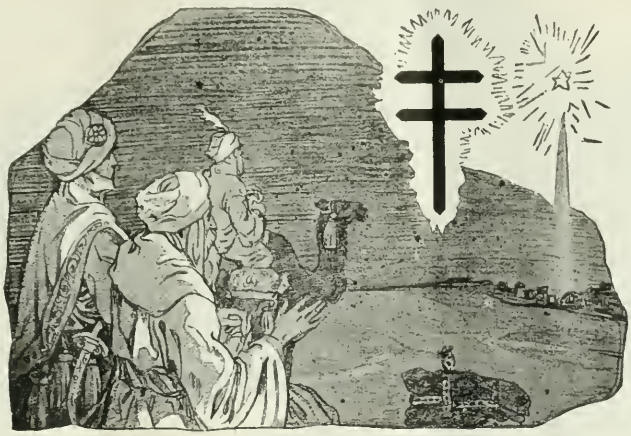

THE QUEST OF THREE WISE MEN

You know the story. Its spirit will go onward through the ages—just as the wisdom of those patriarchs foresaw—a reminder to each of us of the universal brotherhood, that binds us together and makes the suffering of the other fellow ours.

Buy Tuberculosis **Use Christmas Seals**

These seals are the stars of hope—of renewed strength and courage—to thousands of unhappy homes, stricken with the plague of tuberculosis.

Each Christmas Seal you buy helps to stamp out this marauder who robs the lives of over 150,000 Americans every year.

NATIONAL TUBERCULOSIS ASSOCIATION

381 Fourth Avenue, New York

GRAVER
Water
Softening & Purification
HEADQUARTERS

What Type of Water Softener?

Hot Process Continuous
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or Intermittent

OUT of three types of water softeners in accepted steel plant practice there is one, in particular, which will serve you most efficiently, economically and conveniently.

What type that is can be determined only after a thorough analysis of individual conditions by engineers of broad training, familiar with the operation of all types.

The value of Graver Service along this line is attested by the fact that our engineers have been called upon for advisory service by such concerns as United States Steel Corporation, Inland Steel Co., Wisconsin Steel Co., and the American Sheet and Tin Plate Co.

The services of our engineering staff oftentimes effect a considerable increase in the "dividends" paid by water-softening installations, as well as insure their most efficient and economical operation.

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Water Softening and Purifying Equipment

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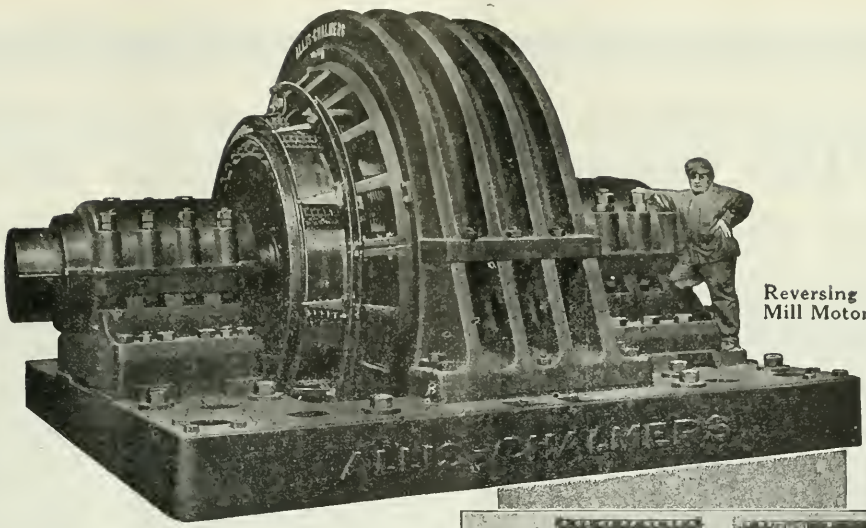
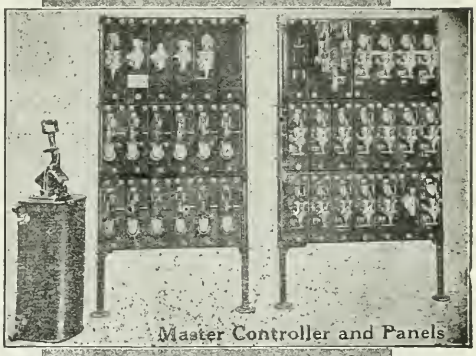


Reversing Plate Mill Motor

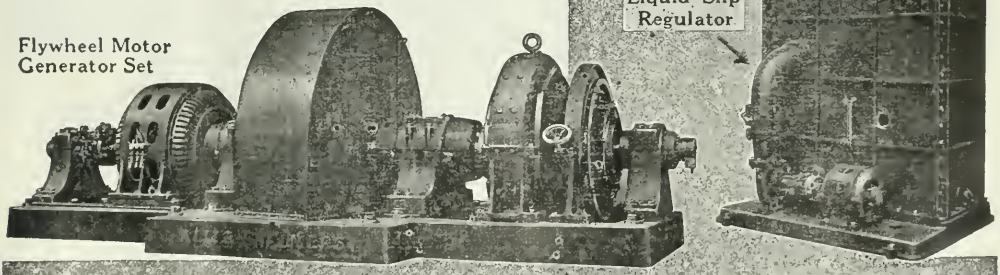
Reversing Plate Mill Drive

Complete Electrical Reversing Equipment for Steel Plate Mill



Master Controller and Panels

Automatic Liquid Slip Regulator



Flywheel Motor Generator Set

ALLIS-CHALMERS

MILWAUKEE, WIS. U. S. A.

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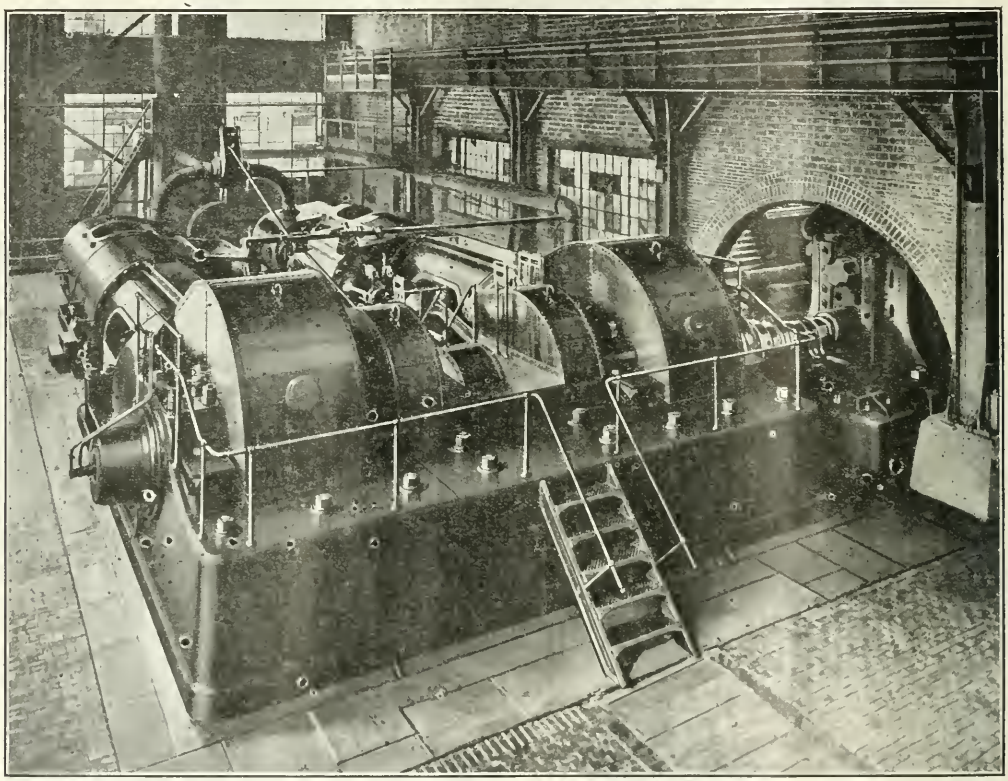
7500 lbs. of Post's "Zero" Metal used on Out Board and Main Bearings, and Post's "Motor Marine" Metal used on Crank Pins of this Superb Engine



46" and 76"x60" Twin Tandem Compound Reversing Engine, built by the Mesta Machine Co., Pittsburgh, Pa.

Post's "Zero" and "Motor Marine" Metals
Carried in Stock at Pittsburgh by

J. FRANK LANNING & COMPANY

327 FIRST AVE., PITTSBURGH, PA.

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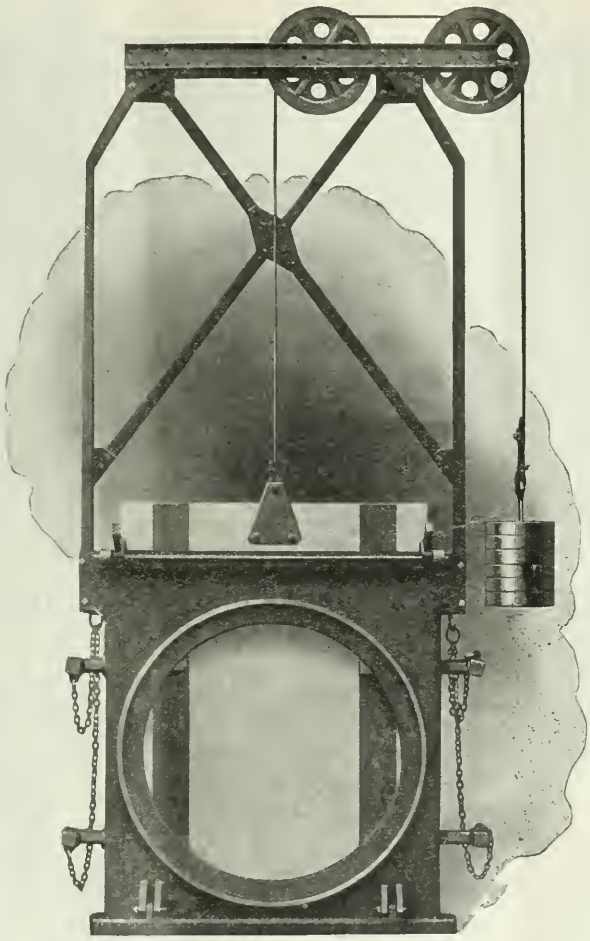
W-S-M Vertical Shut-Off Valve



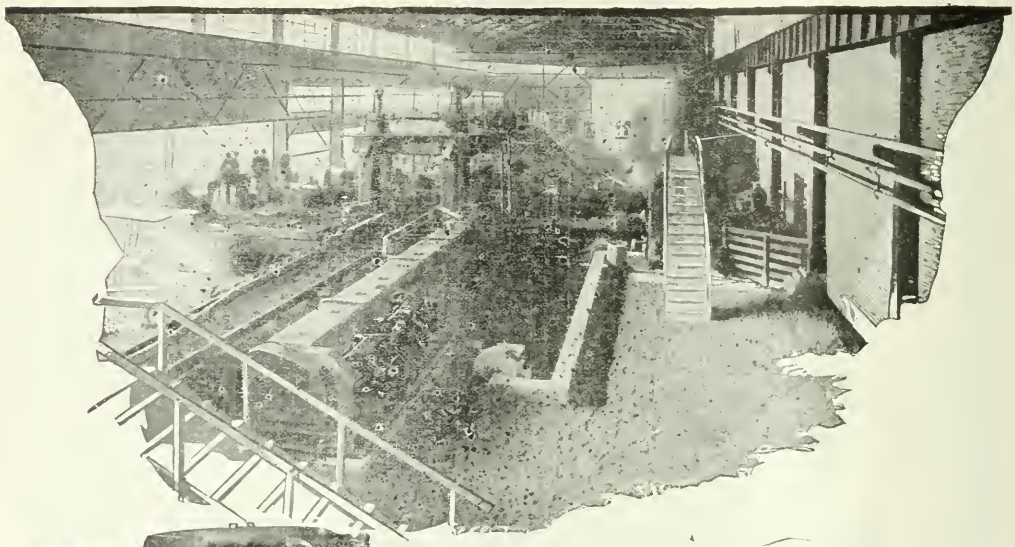
W-S-M Vertical Gas Shut-off Valve, Closed.

The old method of shutting off an individual gas producer by means of a sand damper was a continual source of annoyance. The W-S-M Shut-off Valve overcomes all the objections and dangers. This damper consists of a heavy steel casting which has the necessary flanges for connection to the gas outlet neck and the main gas flue. On the inside of this casting is a machined valve seat while on the top and the bottom are full width openings with hinged covers. The top cover is in two pieces and is hinged to permit the introduction of an asbestos valve plate reinforced by steel bearing plates. The bottom cover is so hinged that it may be dropped from one side to permit the easy removal of tar or foreign matter. By means of four large keys, this asbestos plate may be wedged firmly against the machined seat forming a gas-tight joint. Both top and bottom cover plates are designed so that they may be sealed with clay.

The valve plate may be raised or lowered by means of sheaves and counter-weights mounted on a structural frame on the valve casting.

The Wellman-Seaver-Morgan Co., Cleveland, Ohio

Unexcelled service—tried and proved—has led to the universal adoption of electric motor drive by prominent steel mills



Standard Enclosed Frame DC Mill Motors, Type MD—range from 4 to 175 h. p., 230 and 550 volts.

Standard Open Frame DC Mill Motors, Type MDS—range from 6 to 210 h. p., 230 and 550 volts.

Specially Designed Motors Adaptable to All Work

THE increased production of higher quality at lower power cost, obtained throughout steel mills by the use of G-E motors, is due to the complete adaptability of these motors to the work through series, compound or shunt winding.

For operating screw down tables, the MD motor is especially applicable. This motor used for this work has a heavy mechanical design throughout, a large foundation area, heavy self-contained countershaft brackets, parts easily replaced, small diameter armature to allow rapid reversals, superior commutation, heat-resisting insulations and totally enclosed frame.

A complete line of standard control, either manually or magnetically operated for all classes of steel mill auxiliary drive has also been developed. This equipment assures close power input control without continuous racking of the entire mechanism.

Additional details will be promptly supplied by the nearest G-E office. Write for Bulletin 48121.

General Electric Company

General Office Schenectady, N.Y.

Sales Offices in all large cities

43B-515

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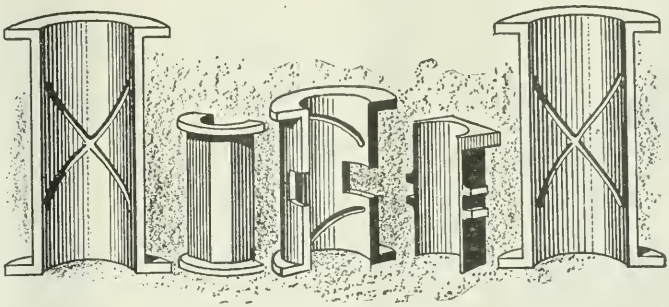
Noheet METAL



Die-Cast Roll Table Bearings

of

"Noheet" Metal

eliminate all machine work on the bearings, give greatly added life to each installation and maintain the roll necks in perfect condition. These bearings are shipped ready for use

It is economies of this character that count.

The Lubricating Metal Company

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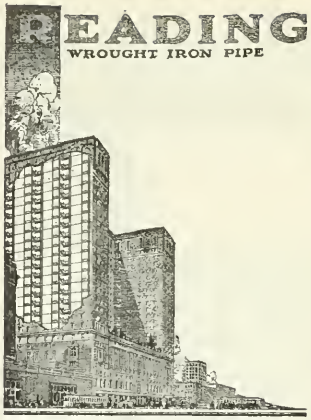
Pittsburgh Cleveland Chicago



Behind the walls of the Commodore and other great New York hotels run miles and miles of Reading Wrought Iron Pipe

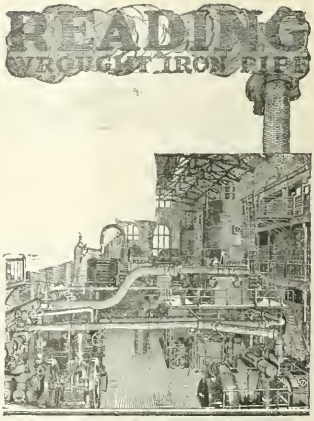
From natural gas field to artificial gas manufactory, Reading Wrought Iron Pipe is prized for resistance to strain and corrosion

In all fields of human endeavor

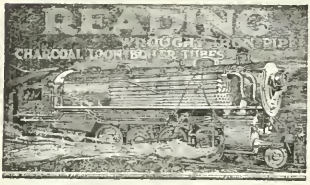
Wherever we live or labor, in home or hotel or office, on railway or ship, in mine or oil field, factory or industrial plant, there Reading Wrought Iron Pipe finds its use.

Ever since 1849 the Reading Iron Company has continued to serve all these industries with genuine wrought iron pipe made from puddled pig-iron.

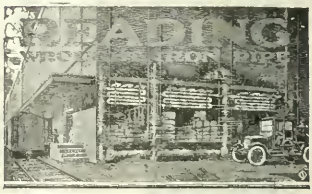
The high quality of this product and the unsurpassed service rendered by it are the same today as in the past and make Reading Wrought Iron Pipe the standard wherever resistance to corrosion and the bending and torsional stresses incident to industrial service are successfully to be met.



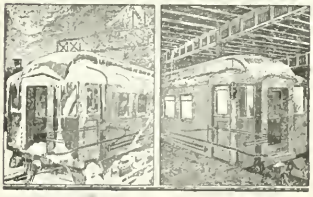
In power plants and water works, where harnessed forces wrench and pound, the staunch endurance of Reading pipe is a necessary safeguard



Within the monster locomotive of today lie hidden thousands of feet of pipe and tubes. Reading Charcoal Iron Boiler tubes are most enduring

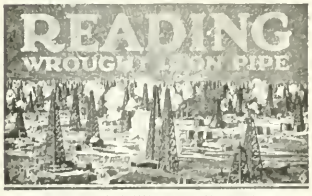


For cold-storage and refrigeration service, where tight joints and resistance to corrosion are vitally essential, Reading pipe solves the problem



Zero weather in icy yards, 175° or more when steam is turned on in the trainshed—Reading pipe endures both extremes

Expensive tiling and parquetry need not be ripped out for repairs to heating and plumbing lines where Reading pipe is installed—it **endures**



From well drilling to oil refining, Reading is specified for endurance and great ultimate economy

Specify Reading—
the Pipe that Endures

Bulletin No. 1
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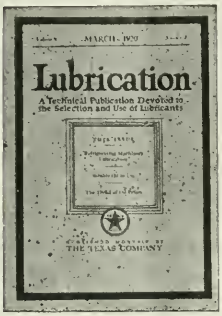

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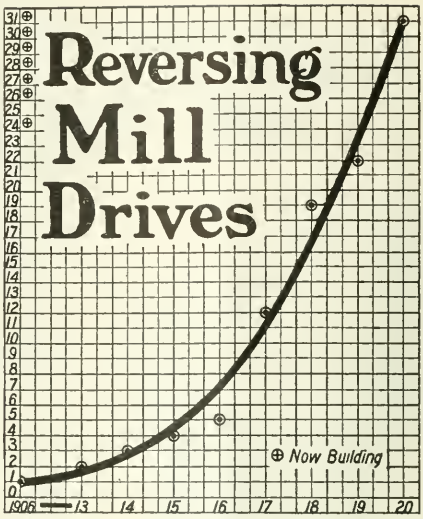

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23	44″ Blooming Mill	1920
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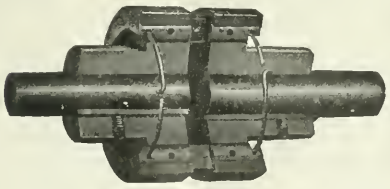

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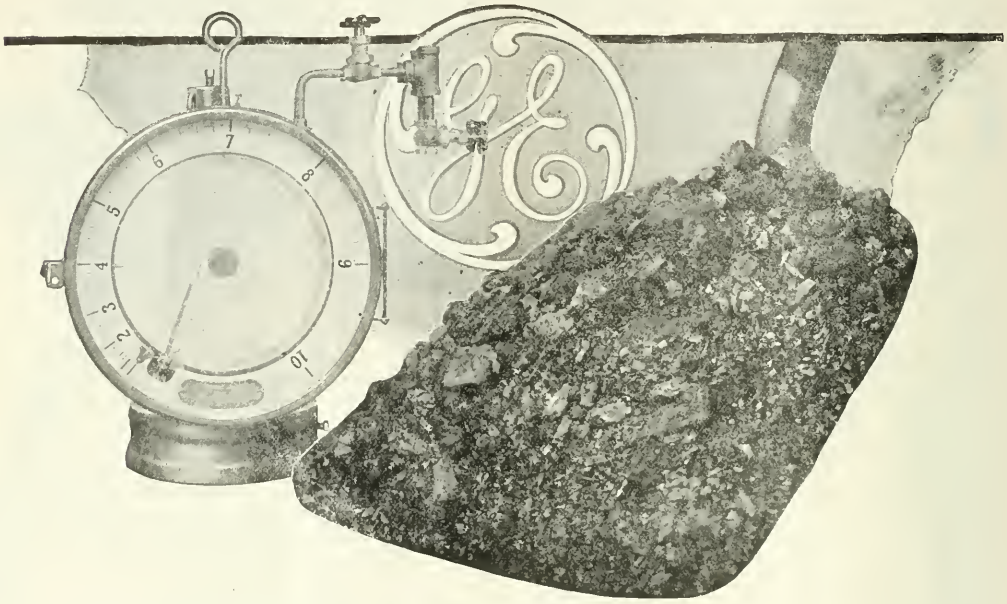

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The Blast Furnace and Steel Plant

The Blast Furnace and Steel Plant

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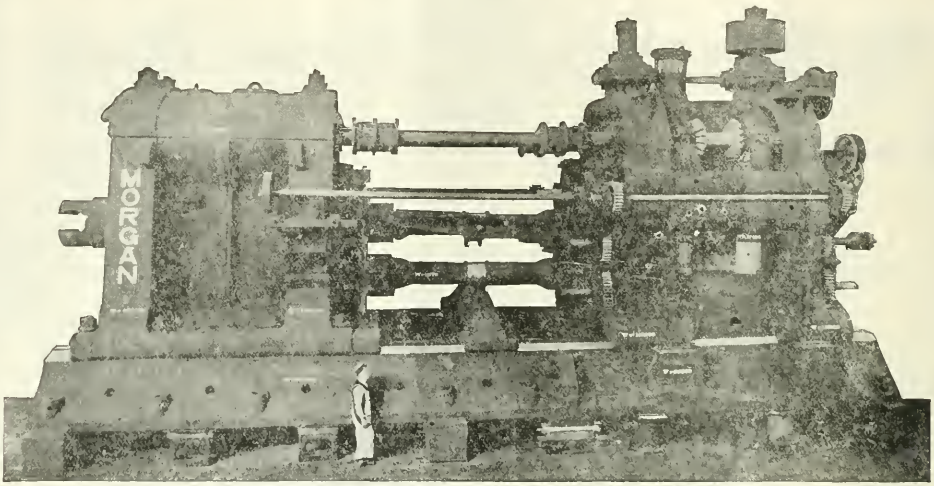

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The Blast Furnace and Steel Plant

VOL. VIII. PITTSBURGH, PA., NOVEMBER, 1920. No. 11

American Iron and Steel Institute Meeting

More Than Fourteen Hundred Attend Eighteenth General Meeting—Valuable Technical Papers Read—Judge Gary Speaks of Conditions Abroad and at Home.

THE eighteenth general meeting of the American Iron and Steel Institute was held at the Hotel Commodore, New York City, October 22.

More than 1,000 persons attended the technical session and over 1,400 were present at the banquet held on Friday evening. The technical program contained some very interesting papers. The papers read were as follows:

"Thrift in Coal," George Otis Smith, Director, United States Geological Survey, Washington, D. C.

"Recent Developments in the Iron and Steel Industry of China," C. P. Perin, New York.

"Foreign Trade," A. H. Holliday, Manager of Exports, Jones & Laughlin Steel Co., Pittsburgh, Pa.

"The Basic Open Hearth Process," F. L. Foy, Superintendent Open Hearth Department, Homestead Works, Carnegie Steel Company, Munhall, Pa.

"A Review of the Development of Copper Steel," D. M. Buck, Metallurgical Engineer, American Sheet & Tin Plate Co., Pittsburgh, Pa.

"The Use of Residual Manganese in Steel Making," E. A. Wheaton, Superintendent Open Hearth Department, Bethlehem Steel Company, Bethlehem, Pa.

"Heat Treatment of Automobile Steels," R. R. Abbot, Peerless Motor Car Company, Cleveland, O.

"The Blast Furnace Hearth,' Walter Mathesius, Superintendent Blast Furnaces, Illinois Steel Company, South Chicago, Ill.

Several of the papers read will appear in this issue of THE BLAST FURNACE AND STEEL PLANT, while others will appear in later issues.

Several very interesting discussions took place after the presentation of some of the papers. While these were limited to five minutes they were equally as well prepared as the original papers.

"Business prospects are unusually bright, both in the United States and abroad," Elbert H. Gary, head of the United States Steel Corporation, declared in his address.

"Although this is a time for courage, composure and caution," Gary said, "the business skies are practically without clouds. As always there may be showers from time to time, but there is nothing in the atmosphere to indicate the approach of dangerous storms.

"If there should be a serious reaction and depression," he continued, "which now seems improbable, it will be the fault of those who are connected with business operations or others who, by reason of official position, improperly interfere, and not because of any fundamental deficiencies in our resources and opportunities.

Healthful Sign.

"In certain lines of the iron and steel industry there have of late been some decreases in the volume of new business and also voluntary reductions in selling prices. I consider this decidedly healthful. All, or nearly all, of us have for months been unable to supply the demands of our customers as to quantities or deliveries, and our prices, considered as a whole, have resulted in profits. As a matter of course, some adjustments will need to be made. The average of the general sale ought to be reduced equitably and relatively.

"Without referring to individual cases or lines of general business, I believe in many instances prices have been outrageously high. This observation applies more especially to middlemen, so called, and to smaller departments of industry. It also includes employes in certain trades; but it does not pertain under present conditions to the masses of workers.

Lower Price Trend.

"The present tendency is toward a lower, more reasonable and fairer relative basis. The difficulty is found in the fact that every individual is perfectly willing that all others shall make reductions—the larger, the better. Now a general public, particularly those who are neither buyers nor sellers to any large extent, will in one way or another bring about a fair and reasonable adjustment of prices. The law of supply and demand will be the principal factor.

"The people of the United States have reason for confidence in the business future. They need not be discouraged nor impatient."

Speedy recovery of industry in France and Belgium from the ravages of war was predicted by Gary. He described in some detail his recent trip over the battlefields of the two countries, where "the surface of the ground was churned into great masses of rough and irregular shapes," expressing surprise that any appreciable progress toward rehabilitation had been made.

Rehabilitation was made possible, Gary said, by the spirit of the French and Belgian people—"the good-natured, grim, persistent and splendid effort to succeed, to restore and to recover."

"I think France has one of the best administrations she has ever had," Gary continued. "The president is strong, resourceful, honest and has the confidence of everyone. The cabinet is made up of good men. We shall see great progress economically, financially and commercially during the next few years.

Developement of Large Furnace Hearths

Successful Development of Large Hearth Blast Furnaces, an Exclusively American Accomplishment, Evoking Keenest Interest of Competitors Abroad, Is Very Completely Described in This Paper.

By WALTER MATHESIUS

ON THE theory of the blast furnace process and its chemical reactions our technical literature contains many able contributions, but little has been said for years about the scientific factors pertaining to furnace design. Perhaps the statement was made occasionally that a blast furnace must afford the opportunity for a uniformly intimate contact between the iron bearing materials of the descending stock column and the furnace gases rising from the hearth. Just how this was to be accomplished, what specific features should be em

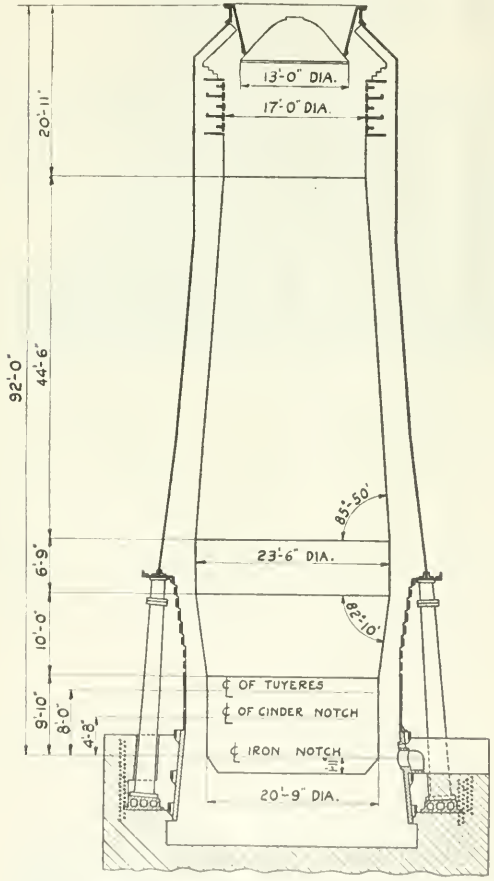

Fig. 1—Showing improved furnace dimensions.

Abstract of paper presented before the American Iron and Steel Institute

bodied in the furnace lines to attain this end, has so far been left almost entirely to the practical furnace man to find out. Thus, blast furnace design has to date been a rather exclusively empirical development.

With a number of examples in successful operation, theory may now safely come to the front and demonstrate that its laws were violated in the past, or that the successful development is logical and correct, its accomplishment scientifically permissible. I shall attempt to show the development of larger furnace hearths to be a logical advancement of the art in its endeavor to design furnaces which will offer the least possible resistance to a rapid and uniformly regular descent of the stock, and which will permit the furnace gases to rise through this stock column with equally regular and uniform velocity and distribution.

The size of the blast furnace hearth has been very largely controlled by the considerations of providing sufficient storage capacity for the molten iron and slag. With greatly increased productive capacity and faster driving and steadily rising difficulties of raw materials, the effect of small hearth diameters in conjunction with the resultant flat or high boshes on the working and economy of our furnaces became more apparent. Yet tendencies toward radical departures from well established standards were most effectively offset by the decided aversion of furnace men to store more than the necessary quantities of molten materials in their furnaces.

This conservative policy was strengthened through the quite popular assumption that gas distribution in the stack could be controlled by maintaining the proper "blast penetration" in the hearth, and that this was largely a question of selecting the proper length and size of tuyeres. Such belief and the failure to recognize the condition of raw materials in the furnace, dependent upon method of charging and furnace lines, as the principal factor governing gas distribution, has only recently been dealt with by J. A. Mohr, in his paper presented before this institute in May, 1919.

There remained the theory that a bosh with sufficient bearing surface was needed to properly support the stock column and to prevent the premature descent of the charges into the tuyere zone, thus avoiding compression and clogging, due to the weight to be carried. This supposition was definitely dispensed with by H. A. Brassert, in his paper read before this institute in May, 1914, where he termed the furnace bosh of that day the chief impediment to a free travel of the stock. Since then it has been the basic idea governing the development of the large hearth, to design, with its aid, a furnace bosh of such steepness and so short, as to avoid interference with the stock movement.

Why the evolution of such designs was naturally and logically linked with the desire to use higher percentages of fine Mesaba ores, may be readily understood on the basis of the following theoretical considerations:

As long as the shrinkage of the stock volume taking

place during its descent from the top of the bosh to the tuyeres is such as to result in a contraction of the total bulk greater than the reduction of the furnace area prescribed by the bosh angle between the two points mentioned, the furnace bosh does not impede the stock movement.

Such shrinkage of the stock volume, may be due to one or two causes. The first of these, supposedly existent in every blast furnace operation, is the gradual consumption of the coke above the tuyeres.

The second cause of shrinkage is the gradual melting of the ore and the formation of slag. It may be readily seen that this shrinkage can take place to an appreciable extent only in furnaces where all or a large part of the burden consists of lumpy material, which does not disintegrate in the furnace stack.

If all or a large part of the burden consists of fine materials, the voids existing in the coke charge will offer sufficient volume to receive it, so that, as the stock column descends, the space occupied by ore and coke is practically no greater than that of the coke charge. Consequently, the melting of the ore in the bosh cannot bring about any shrinkage of the stock column. Modern Mesaba practice with high blast heats and low fuel rates, will be seen, from this purely mechanical point of view, to present all of the above mentioned conditions which tend to minimize the shrinkage of the stock in the bosh and to retard its beginning. Thus, evidently Mesaba practice, more than other operations, was in need of lower and steeper boshes and practical experience has shown that their adoption has in every case resulted in improved quality of product, increased tonnage, lower fuel consumption, and better use of hot blast temperatures, as stated and proved by Mr. James G. West, in his paper read before this institute in May, 1918.

One of the incidental yet not negligible advantages of the larger hearth is its greater accessibility. With increased diameter, greater peripheral distances result for arranging feed and discharge pipes for cooling water, more working space is available around the tuyeres, blow stocks, and the columns as well as between the iron and cinder runners near the furnace, so that the cast house work and also the mechanical maintenance becomes easier and simpler.

In order to illustrate the extent to which hearth dimensions have grown in recent year, I might mention that the average hearth diameter of all 22 ft. bosh furnaces at the South Chicago plant of the Illinois Steel Company was increased from 16′ 6″ in 1911 to 18′ 6″ in 1919, and that the best average monthly production of these same furnaces equaled 512 tons per furnace day in December, 1911, as against 556 tons in May, 1920. For this increased output the adoption of larger hearths is primarily responsible, no enlargement of the furnaces or important changes of lines above the bosh having been made. During the same time our fuel conditions have developed no permanent improvement but have rather experienced a decided change for the worse. The fuel consumption per ton of iron for the two periods cited above were 2053 pounds in December, 1911 and 2037 pounds in May, 1920.

So far this discussion has dealt with changes of hearth and bosh dimensions which did not contemplate or entail any changes in the upper, that is the stack part of the furnace. Later however, larger hearths have also enabled modifications of the stack lines, which were not practicable before, although their desirability had been felt for some time. Particularly for operations where soft, easily reduced ores are used which are known to have a tendency to swell under the influence of the reducing furnace gases, the suggestion had been made that the uniform descent of the stock might be facilitated by increasing the batter of the stack lining, thereby reducing

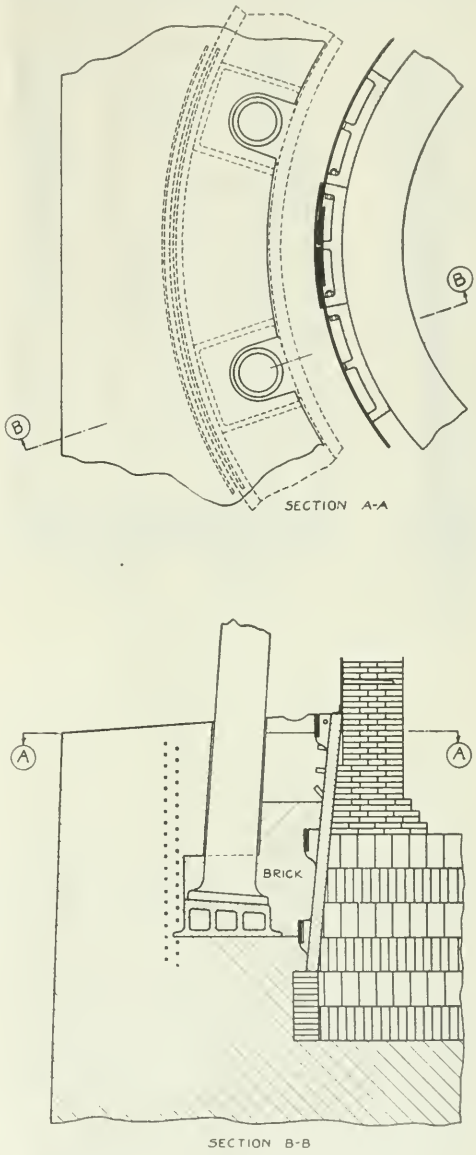

Fig. 2—Showing position of circular beam of concrete.

any "jamming" tendencies as well as friction. One way to obtain this would seem to require merely a decrease in the diameter of the stock line. This did not appear to be permissible on modern fast driven furnaces, using a

large percentage of fine ores, since the gas velocity at the stock line was known to be so high as to keep the surface of the charge in more or less constant agitation. Thus, the limit would be closely approached beyond which dust losses would rapidly grow to excessive proportions. The diameter of the bosh, on the other hand, appeared to be

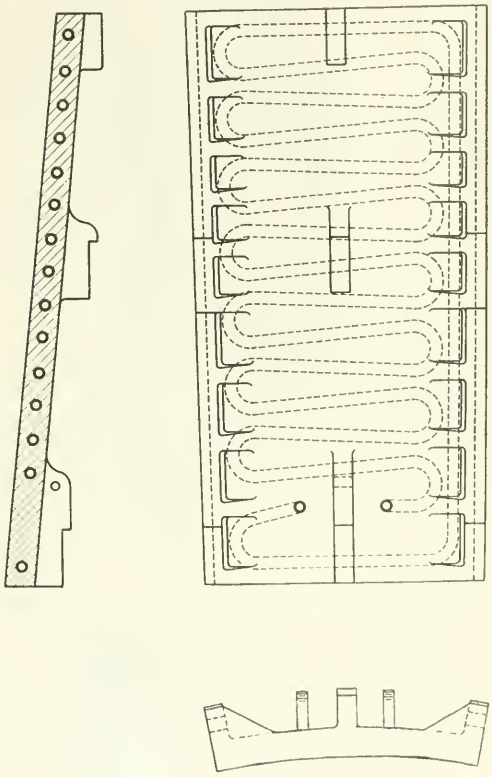

Fig. 3—Common design, abandoned by the author.

definitely controlled by the limits of hearth dimensions and bosh angles. The only remaining means of obtaining at least a slight increase in the stack batter was to carry the straight stock line section down lower into the furnace.

Hearth diameters of 20 feet and larger are in satisfactory operation and the opportunity is here to increase the bosh diameter over the 22 ft. standard without sacrificing anything in suitability of bosh angle or height. The result to be expected from such designs, should be a freer working of the furnace and a lower blast pressure. Practical results appear to verify this analysis, since No. 6 blast furnace at the South Works of the Illinois Steel Company, which was designed along such lines of reasoning, and has now been in operation for about two years, has consistently worked with a more regular and uniformly lower blast pressure than the other furnaces at this plant under comparative conditions. The principal dimensions of this furnace are given in Fig. 1.

Although the number of large furnace hearths installed has increased during recent years, some furnacemen maintain a skeptical attitude and occasionally voice objections with substantial arguments.

One of the most frequently heard assertions is, that the large hearth furnaces must necessarily suffer from lack of penetration, and that this ailment can be alleviated only by either considerably overblowing or by reducing the tuyere size to such small dimensions as to create a pronounced "jetting" action.

Calculations based on authoritative tests concerning the flow of air through orifices show that under average conditions of Mesaba practice, this pressure drop is less than 10 per cent of the total blast pressure which has been verified by taking pressure readings on operating furnaces. Since it is also a scientific fact that the energy of the air-flow through an orifice varies directly as the difference in pressure before and after the orifice, it will be readily seen that a doubling of the penetrating ability would require only a small increase in total blast pressure. However, practice on our largest hearth furnace in South Chicago has conclusively demonstrated that no such additional penetrating energy is required. Based on an equal volume of wind blown, it was found best to use a slightly

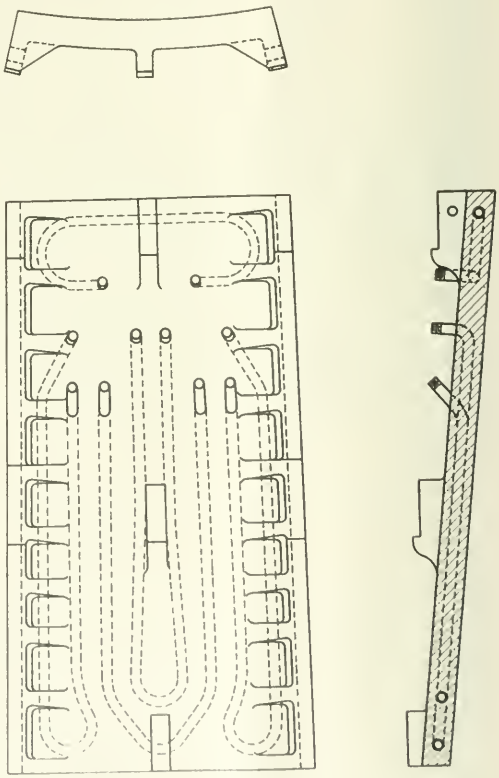

Fig. 4—Showing type at present being installed.

larger tuyere area than on other furnaces with smaller hearths. The only possible explanation for this seems to be that the materials are not packed as tightly in the large hearth and actually offer less resistance to the blast.

Another point which has been raised as indicating the fallacy of the large hearth design, is the fact that on

many large hearth furnaces the tuyeres, extending from 9 to 12 inches into the furnace proper, are longer than those in use at other plants. The assertion has even been made that the "jetting" action together with the long tuyeres, produces "phantom" boshes, the actual working lines of the furnace having a much flatter bosh angle and smaller hearth than those provided in the design.

We are able to use longer tuyeres on furnaces with hearth diameters ranging from 17′ 8″ to 20′ 9″, on account of our steep and low boshes. Without these, shorter tuyeres would have to be used in an attempt to keep the bosh clean and prevent the formation of accumulations, the periodical building up and sliding off of which was formerly a source of continuous trouble at many plants. How the use of such short tuyeres in numerous instances resulted in "working too close to the bosh" cutting out the brickwork between the bosh cooling plates and leaving the latter sticking out into the furnace, is no doubt well known to many furnace men. A bosh in this condition becomes harder to keep clean. Troubles resulting therefrom have been charged to overcooling of the bosh.

While I fully believe that overcooling is disadvantageous, I do not think that a decrease in the number of

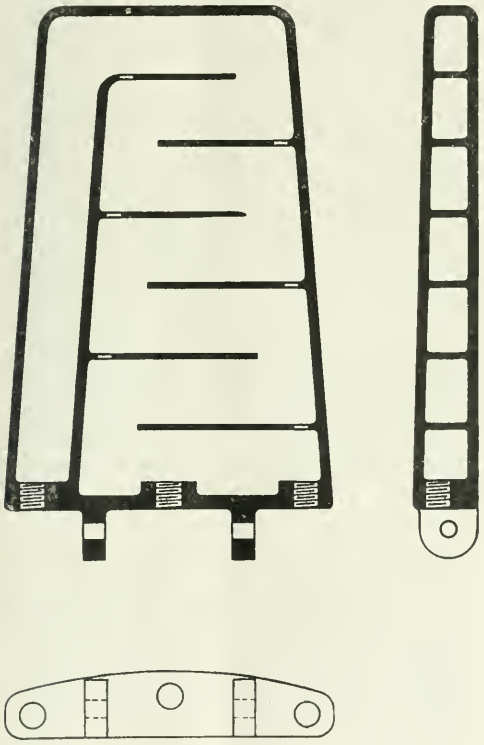

Fig. 5—Bosh plate design being abandoned.

bosh plates used and a corresponding increase in the size of the unprotected areas between such plates is the proper remedy. We are using a closer spacing of bosh plates than is customary at many plants. With this construction we have eliminated to a large extent the shelf formation due to erosion, as well as the evils of overcooling, by not "working too close to the bosh." This, we believe to have accomplished by the use of longer tuyeres. We have had the opportunity of late to inspect, during the repairing of several of our furnaces the bosh linings after successful campaigns and blowing out on account of business conditions. It was clearly apparent that all the

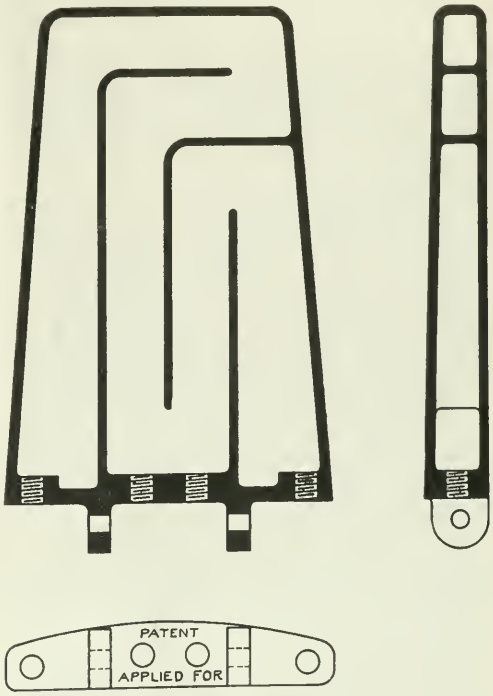

Fig. 6—Bosh plate design supplanting that of Fig. 5.

cooling plates had been completely coated during the operation of the furnace; erosion was practically absent, so that the interior of the bosh presented a uniformly smooth surface which could offer little or no resistance to the travel of the stock. The same inspections have in my opinion also furnished ample proof that the "phantom boshes" and "automatically reduced hearth dimensions" which have been theorized about, do not exist in our furnaces.

It has further been asserted that with an increase in hearth diameter it would be necessary to add to the number of tuyeres in order to avoid too great a distance between them. In reply to this I can only state that on four of our furnaces at South Chicago, where the distance between the centers of adjoining tuyeres, measured on the periphery of the hearth was 4′ 7¾″, 4′ 11¾″, 5′ 10⅝″. Inspection after blowing out did not show any such formations. On our No. 6 furnace, where with 20′ 9″ hearth diameter and 10 tuyeres the distance between tuyeres amount to 6′ 6¼″.

Another statement which has been made in literature is that large hearths are not capable of maximum heat concentration and that for this reason a poor quality of fuel would here be more likely to give serious trouble through building up in the bottom than would be the case

with smaller hearth dimensions. For the same reason large hearths were said to be not as well suited for the manufacture of foundry iron and other high silicon grades. So far I have not been able to find a satisfactory explanation or theory as to how a small hearth favors maximum heat concentration, and am unable to discuss this question.

As to the ability to operate under adverse conditions of raw materials, little can be added to the statements made in Mr. West's paper and the discussions presented therewith before this institute in May, 1918, except to say that furnace operations since have only furnished additional proof of the assertions made on that occasion. The same is true regarding the question of manufacturing foundry iron, which at that time was fully covered by G. L. Collord.

In summing up these arguments I do not intend to deny that conditions may exist where in normal operation furnaces with high or flat boshes and small hearth dimensions work entirely satisfactory and compare well in results with those accompiished in Mesaba practice by furnaces with larger hearths. The fact remains that in a great number of instances, and under different conditions of raw materials, practice and products, the larger hearth has been the means of obtaining improvements in output and economy, which were not realized before.

It should be emphasized that the enlargement has not imposed additional or increased stresses and duties, while in some respects the demands upon the strength and wearing qualities of the construction have actually lessened. The volume for storing the molten iron and slag being larger, the maximum height to which these latter will rise above the low level prevailing at the end of the cast, must for a given production necessarily be lower. Thus, less pressure is exerted per square foot of bottom and hearth walls, and there is less danger of metal reaching the level of the cinder notch or of slag interfering with the combustion of coke at the tuyere level.

These dimensions must necessarily be kept below a well defined maximum, otherwise the metal bath being removed too far from the zone of highest temperature, becomes the cause of producing physically cold iron, which is the source of many evils and worries in steel works as well as blast furnace practice.

Having made provisions for storing larger quantities of molten metal in the furnace and having reduced the number of casts per day accordingly, it becomes naturally of utmost importance to leave nothing undone towards minimizing the danger of iron breakouts. To obviate this most hated of all furnace troubles requires uninterrupted, effective watercooling and ample mechanical strength. The latter should preferably be provided in such a way that a possible failure of the former at any one point with resultant local heating and perhaps an incipient breakout, will not at the same time reduce the strength of the mechanical bend. It is apparent that this might readily be the case where cast iron watercooled staves are placed immediately inside of a steel hearth jacket, or where watercooled hearth jacket sections are encircled by bands placed directly on the jacket itself. To eliminate this risk we have developed a design which has been in use for several years which consists mainly of a substantial circular bean of reinforced concrete placed at some distance from the watercooled cast iron hearth jacket, as shown in Fig 2. The space between this concrete reinforcement and the hearth jacket is bricked up with fire brick, so that any radial pressure exerted on the hearth jacket, or expansion stresses of the latter, are directly transmitted to the concrete girdle. Provision is made by allowing clearance on the furnace side of each column, that no side thrust can be transmitted to them.

In order to reduce the chances of interruption in the watercooling of the hearth jacket segments, we have abandoned the design as shown in Fig. 3, because it was found impossible at times to remove obstructions carried in with the water, from the many bends and angles of the cast-in cooling pipes. In its place we are now installing the construction illustrated in Fig. 4. It will be seen that only simple hairpin loops of pipe are used in this design, so that in case of stoppage each pipe is accessible its entire length from the outside. Also, should it be found impossible to remove an obstruction from one of the loops, it is no longer necessary to discontinue cooling the entire section.

Following similar lines of reopening we are replacing the bosh plate design as shown in Fig. 5, by that illustrated in Fig. 6. As may be seen, this type of plate is readily accessible for cleaning out, by taking out the pipe plugs provided for this purpose. Accumulations of solid matter may be readily removed during operation. Furthermore, these plates have the advantage of a positively controlled flow of water and no core holes are required in the baffle plates.

The baffling of the plate in the new design is arranged parallel, instead of at right angles to the line of withdrawal from the brickwork. Furnace operators who, on account of adverse water conditions encounter the necessity of frequent bosh plate changes, will appreciate this feature, as it effectively supports the arched surface and prevents identations.

The results obtained so far justify the belief that permanent progress has been achieved to the lasting benefit of the American Iron and Steel Industry.

L. C. Crewe was recently elected president and general manager of the Woodstock Operating Corporation, Anniston, Ala., at a recent meeting of the directors. He formerly held the position of vice president and general manager of the same corporation. Mr. Crewe is also president and general manager of the La Follette Coal & Iron Co., LaFollette, Tenn. S. S. Pratt, treasurer and assistant general manager La Follette Coal & Iron Company, is also treasurer of the Woodstock Operating Corporation. C. S. Martin, Gary, Ind., has been appointed general superintendent.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

The Blast Furnace and Steel Plant

[Required by the Act of Congress of August 24, 1912]

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Managing Editor—Herbert A. Andresen, 108 Smithfield street, Pittsburgh, Pa.

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Names and addresses of stockholders holding 1 per cent or more of total amount of stock:

Herbert A. Andresen, 108 Smithfield street, Pittsburgh, Pa.

Fred C. Andresen, 108 Smithfield street, Pittsburgh, Pa.

Known bondholders, mortgagees, and other security holders, holding 1 per cent or more of total amount of bonds, mortgages, or other securities: None.

FRED C. ANDRESEN, Business Manager.

Sworn to and subscribed before me this 30th day of September, 1920.

JOHN N. ENGLISH, Notary Public.

(My commission expires March 9, 1923)

Review of the Development of Copper Steel*

Discussing the Results of Various Researches Since 1900 and Advising the Adoption of Copper Bearing Steel in Other Sections Than Sheets—Bibliography of Recent Literature.

By D. M. BUCK

THE annual economic wastage due to the corrosion or rusting away of various finished products made from steel and iron, if it could be expressed in monetary value, would no doubt be appalling. One prominent investigator has roughly estimated that the annual charge due to corrosion is between 60 and 90 million dollars, based upon normal values of semi-finished products, and this figure takes into account only the actual value of the iron and steel itself without reference to other closely related losses. Although this aim has not yet been obtained, tremendous strides forward have been made in the past fifteen years. The problem has been attacked from several different angles, but I believe the results of careful investigation justify the statement that, in the light of our present knowledge, considering the average materials of construction, the best results are obtained by alloying with normal open hearth or bessemer steel, from 0.15 to 0.30 per cent of pure copper. The commercial application of this discovery was first announced by the Company which the author represents in 1911, and during that year it was placed on the market in short form.

It is the intention of this paper to present in a brief form the more important evidence which proves the remarkable influence of copper additions to steel and iron, in checking the attack of atmospheric moisture and oxygen, and to heartily urge the more general adoption of copper steel in other sections than sheet metal, to which uses it has largely been confined up to the present time.

Although there are numerous references in literature, beginning with the year 1627, to the effect of copper on the physical properties of steel and iron, nothing definite is found pertaining to its control of corrosion previous to the present century.

Various papers since that time cite the results of tests made, from which the following conclusions are drawn:

1. Copper in soft Bessemer steel lessened corrosion.
2. Copper steel resists the action of sulphuric acid.
3. Bessemer and open hearth copper steel (.15 to .30%) show decided superiority against corrosion under actual service conditions.
4. Corrosion of electrolytic iron is reduced by alloying with various amounts of copper, nickel and manganese.
5. Durability of old steel fence wire is due to the presence of copper.
6. Steel with as little as 0.03% corrodes only 60 to 70% as fast as steel containing 0.01% copper. 0.15% Cu is recommended as a minimum content from the corrosion standpoint and it is not necessary to greatly exceed this figure.
7. Life of unprotected sheet metal having a copper content of from 0.15 to 0.25% is increased from 300 to 500 per cent while the increase in the cost over that of ordinary steel is not more than $2 to $3 per ton.

While it is undoubtedly true that the greater portion of steel and iron products exposed to corrosive conditions is, at least initially, covered by some protective coating, it is equally a fact that these protective coatings are unfortunately only transitory protection, and wherever unprotected metal is exposed, or after the paint or metallic protection film has worn away or become damaged, thus exposing the bare iron or steel, such additional life as can certainly be obtained by the simple alloying with copper becomes of paramount importance and of almost incalculate value.

It may not be out of place to state that in addition to the added resistance of copper steel to corrosion, the author has noticed in his investigations, indications which point to a better adherence of paint coatings on copper steel, thus resulting in a more perfect and longer continued protection by the paint film.

The benefits to be obtained by adding copper to normal steel, to be fabricated into materials of construction, cannot be successfully contradicted. The melting point of copper is approximately 700 degrees F. lower than the average tapping temperature, it diffuses readily, and once diffused does not segregate.

The manufacture of copper steel has heretofore been largely confined to sheet metal, and the product has been tremendously improved. The usefulness of this discovery may readily be broadened by the use of copper in other steel and iron sections, and their life thereby greatly increased. To mention a single example, steel freight cars, especially those of the open type, suffer greatly from corrosion. If the life of the thousands of such cars that have passed out of the field of usefulness during the past few years could have been increased only 20 to 25 per cent, the result would have gone far toward relieving the severe car shortage which has recently existed. Such a result would probably have been obtained had copper steel been used in their manufacture. We have here, a comparatively inexpensive method of improving all of our products that are called upon to resist the attack of air and moisture, thus greatly increasing their period of service and at the same time effecting an immeasurably important step in the conservation of our natural resources. The author's wish in presenting this paper is to respectfully urge your earnest consideration of these suggestions.

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*Paper presented at the American Iron and Steel Institute, October 22, 1920.

†Mr. Buck is Metallurgical Engineer of the American Sheet & Tin Plate Co.

Our Possibilities in Foreign Trade

Competition That Is to Be Encountered—The Part a Strong Merchane Marine Plays in Foreign Trade—Due to Over Production America Must Find Foreign Markets.

By A. H. HOLLIDAY.

IF the United States is to manufacture at her maximum capacity of production, and that maximum be greater than she can consume internally at all times, it follows that she must have other fields in which to market her goods.

With the war came larger production, the result of increased manufacturing efficiency and enlarged investment. Our yearly average production for the five war years exceeded the average production for the five pre-war years to the extent of 10,336,513 gross tons. Production during 1918 exceeded the 1913 figures by 13,161,558 gross tons.

1. Present normal demand.
2. Replacement of world's loss of production during war years.
3. The inevitable increase due to rehabilitation.
4. Natural expansion of demand.
5. The development of countries hitherto virtually undeveloped, but now awakened or awakening to full national consciousness.

1. The present normal demand we can readily gauge by figures in evidence before the war.

2. The world's loss of production to peaceful arts is difficult of determination, but with the figures of world production now quite fully obtainable for the war years we have evolved the following theory of analysis and computation of the loss based on steel ingot and casting production:

For the United States, the United Kingdom, France, Germany, and Russia, the diversion of production from peaceful arts to war purposes.

For Belgium, non-production.

The application is as follows:

Steel Production of the World and Estimated Loss to Peaceful Arts during World War Period, 1914-1918.

Countries	Prduction* (Gross Tons)	Loss to Peaceful Arts (per cent)	Loss (Gross Tons)
United States	187,960,785	50	93,980,393
United Kingdom	44,977,092	66 2/3	29,984,728
Germany	74,655,839	100	74,655,839
Belgium	1,585,207	Total at pre-war rate of production	10,582,255
France	9,581,775	100	9,581,775
Russia	17,744,196	66 2/3	11,829,464
Total	336,504,894		230,614,454
All other	31,187,924	66 2/3	20,791,948
Grand total	367,692,818		

*Steel ingots and castings.

The production of the world, as above outlined, amounted during the war years to 367,692,818 gross tons. Allowance for unavoidable inaccuracies of various kinds must be made in reaching conclusions. We must also make allowance for the reclamation of steel diverted to war purposes.

However, by disregarding the odd 51,000,000 gross tons of the total estimated world's loss of production above obtained, we arrive at what we believe to be a safe minimum of 200,000,000 gross tons lost to peaceful arts. All or most of this tonnage is likely to be required by the world, in addition to the demand that otherwise would exist. This tonnage will exercise a strong supporting influence on the world's markets for many years to follow.

3. Rehabilitation has probably been much overestimated and will likely prove to be of interest on a rapidly diminishing scale to the steel manufacturers of the United States, as war's destruction will be supplied largely by the several countries affected or by their European neighbors. Nevertheless, in terms of world supply and demand this condition will have an influence beneficial to the industry as a whole.

4. Natural expansion can be gauged measurably by the upward curves of world production and consumption in the years preceding the war.

5. The further development of countries hitherto but little developed or now in condition of political, social, and economic chaos, coupled with the expansion of those countries in which substantial progress has already been made, is a subject which staggers the imagination, but which in its very nature is indeterminate at present. By way of illustration, the per capita consumption of China and Japan for 1918, based on the conservative estimate of 383,000,000 combined population, was 6.5 pounds of finished steel as compared with the United States per capita of 517 pounds for 1913 based on 98,000,000 population. Gauged by population, natural resources, increasing national consciousness, with expanding economic development, the human desire for comforts and luxuries, we may fairly conclude that the world's every effort toward increased steel production will be assimilated quickly with an insistent demand for still further tonnages.

Competition.

Obviously, for our purposes, the nations of the world divide into two classes: Manufacturing and non-manufacturing. The United States, Canada, the United Kingdom, Germany, France, and Belgium, with Russia in the background, embrace the former, while, broadly speaking, the remainder of the world embraces the latter.

One most important economic principle is, that productivity, by enabling the interchange of commodities with others, is a sound basis for human prosperity and happiness. Hence, in addition to our own efforts in this direction we should encourage foreign lands to produce in exchange for our own products those commodities which we can ourselves use or dispose of to others and we should supply the machinery, financial and otherwise, for this interchange. This has an acute present application in view of the general dislocation of finance throughout the world.

Abstract of paper read before American Iron and Steel Institute, October 22, 1920.

We have been slow to take advantage of the opportunities forced upon us by the war. We have not yet surrounded ourselves with the atmosphere of foreign trade. In consequence we suffer by comparison with those other manufacturing nations to whom foreign trade is their life blood and whose every activity is directed to that end.

Substantial Accomplishments.

Our government suffers by comparison with other governments, because its course has been one of ill-advised interference with the natural enlargement of business interests as opposed to the splendid, constructive helpfulness of other governments toward their citizens and subjects.

The Webb-Pomerene Act provides for associations for foreign trade. The restricted powers originally granted the Federal Reserve Bank have been amplified by the Edge Bill, permitting long extended credit periods. The Merchant Marine Act, 1920, aims to give point and direction to our marine activities. All of these are constructive in intent and, while faulty and inadequate in some respects, nevertheless give promise of better things.

Merchant Marine.

One of the conditions precedent to successful foreign trade activities is that we export and import largely in our own bottoms. The events of the war sharply emphasized this fact. A recent summarizing of the returns of the Bureau of Navigation as quoted by the "Journal of Commerce" (New York, September 16), is in part as follows:

"At the end of the fiscal year, June 30, 1920, the total American registered, enrolled, and licensed shipping consisted of 28,182 vessels of 16,324,013 gross tons, compared with 27,513 vessels of 12,907,300 gross tons on June 30, 1919."

This is an increase of 669 vessels of 3,416,712 gross tons.

The "Journal of Commerce" then comments editorially in part, thus:

"This statement contained in a Washington dispatch summarizing the returns of the Bureau of Navigation shows that the much desired merchant marine of the United States is a reality so far as the actual tonnage of the fleet is concerned. We have a large volume of registered tonnage, and so far as carrying capacity is concerned there is no reason why we should feel any doubt of our future."

And it further proceeds to assert that there is nothing to fear regarding shipbuilding and operating costs, lack of men or cargoes, if properly supported by government, we whole-heartedly devote our energies to the task.

Ships are necessary to carry cargoes. Men are necessary to operate ships. Cargoes are necessary to supply ships and men with opportunity. Any one of this cycle of supply and demand is necessary to the welfare of the others. Prior to the war virtually we had neither ships, men, nor cargoes. Now we have substantial nuclei of all three.

Departmental Aid.

The Bureau of Foreign and Domestic Commerce is to be commended for its manifold activities in support of foreign trade. Unfortunately, too little is known by the business public regarding this important agency and the help that it can render by its ingathering and outgiving of information valuable to manufacturers, importers and exporters generally. The bureau is a necessary adjunct to manufacturing and commerce; hence its efficiency will undoubtedly increase to meet the demands made upon it.

Banking.

It is fully recognized that American banks abroad are of the bone and sinew of our foreign trade. To cope with the highly organized and ever extending foreign banking systems of European countries, we must have American banks of highest efficiency, with adequate resources, in foreign countries, especially those of the non-manufacturing class.

The following American banking houses have established branch banks abroad: The National City Bank, with its affiliate the International Banking Corporation, 80; the Guaranty Trust Company with its affiliates, the Mercantile Bank of the Americas and the Asia Banking Corporation, 47; the American Foreign Banking Corporation, 18; the First National Bank of Boston, Equitable Trust Company, Farmers Loan and Trust Company, and Park Union Foreign Banking Corporation also are represented in the foreign field by branch banks. The whole number thus established is 153.

In addition American banks are represented in every quarter of the globe by means of direct connections with banking institutions of the respective countries, which are of the highest standing, and, therefore, have at their command the full resources and assistance of these long established and influential banks.

Education.

Prompted and supported by such agencies as the National Foreign Trade Council; the United States Chamber of Commerce; our Government, as evidenced in part by the Conference in Training for Foreign Service called by the Commissioner of Education and held in Washington December 31, 1913, and Dr. McElwee's book, "Training for Foreign Trade," (Department of Commerce, 1919), schools and colleges, banking houses, manufacturing, commercial and other institutions have come to the front with required educational facilities. Before we realize it we shall have a rapidly increasing body of men and women speaking various useful languages, familiar with commercial geography, educated in world commerce procedure, ready for foreign trade service either at home or abroad.

There is only required care that such education be not merely academic but practical, so that results may follow quickly and the employe, undiscouraged, spurred on to greater efficiency.

Conclusions.

One of the finest guarantees of the foreign trade principle, its validity and its continuity, is the note of high altruism which during recent years has been sounded in public and private utterances. It is no longer export trade but foreign trade. We have ceased to hear that "there is no sentiment in business." Instead, constructive helpfulness is emphasized. We are imbued with the world spirit.

"Where there is no vision the people perish." As well religion without belief in the supernatural, as foreign trade without optimism. The issue is very real and will require courage for its successful accomplishment. We have moved but a small part of the way, but we have the natural resources, the wealth, the mills, the executives and the workers, with their combined inventive genius, the railroads, the ships and those to man them. If we do not seize the opportunity, others will.

Use of High Manganese Iron in Basic Open Hearth Practice

Problem of Avoiding Future Increases in Fuel Sulphurs by the Utilization of High Manganese in the Initial Open Hearth Charge, Which Means Reduction in Tonnage and Increased Costs.

By E. A. WHEATON.

STEEL producers have been and are face to face with a problem steadily increasing in difficulty: the growing scarcity of low sulphur fuels.

Many steel users attribute most of the failures experienced in service to sulphur in steel, and that many manufacturers believe that the sulphur limits current in various specifications for steel, represent limits which cannot be exceeded without a distinct loss of tonnage in forged and rolled products due to the "red shortness" classically attributed to sulphur content. This loss is a concern of both the consumer and producer.

An important consideration, is the problem of avoiding future increases in fuel sulphurs.

The problem has received much attention both in the endeavor to produce low sulphur pig irons without undue increase of cost and undue loss of quantity production; and in the endeavor to produce low sulphur steels from high sulphur pig irons without loss of quality or tonnage.

The objectors to the utilization of high manganese in the initial open hearth charge have substantiated their position on account of increased costs and the alleged reduction of open hearth tonnage; or relied upon the selection of high grade raw materials and satisfactory low sulphur fuel, to facilitate the production of the relatively small tonnages of high quality products. The necessity of paying attention to the manganese consideration, or some other desulphurization method, will be forced by the increasing difficulty of locating sufficient quantities of high grade materials and fuels and their increasing cost.

While the amount of sulphur contained in steel has been the subject of extended investigations and while many different sulphur contents of steel, it is a generally accepted fact by the industry that within reasonable limits the main effect of sulphur is to react against the operation of the rolling mill or of the finishing department rather than to affect the serviceability of the steel once it has passed a reasonable inspection. This penalty, steel manufacturers have been prone to accept as unavoidable rather than to exhaust other resources such as the utilization of manganese in the initial open hearth charge for the elimination of their manufacturing difficulties.

In the face of increased difficulties in obtaining high grade raw materials and in the effort to produce the highest quality of products requiring special inspection and for the special service, and believing that certainly some of the difficulties might be overcome by the use of a high manganese pig iron, the Bethlehem Plant of the Bethlehem Steel Company undertook to operate the No. 3 Open Hearth for a considerable period of time in the manufacture of steels where the inspection and service was particularly severe and where the affect of any improvement of quality would be most readily demonstrated. The data presented herewith extends over several months' experience but particularly refers to the month of August 1920, as our records are kept in monthly periods and as the experiment is complete in itself in that period, inasmuch as nothing but high manganese pig iron was used at that time.

Paper read at American Iron and Steel Institute, October 22, 1920.

From the data presented herewith the writer has drawn the following conclusions:

First—That high manganese iron is a help rather than a hinderance in blast furnace practice.

Second—That high manganese iron improves the quality of open hearth steel without reduction of tonnage or practice or other injurious effects.

Third—That to meet the demands for the better grades of steels, alloy, etc., it is of very great assistance.

Fourth—That, due to better surface conditions, steel made from it shows increased yields with ordinary rolling mill practice.

Blast Furnace Operation.

With high sulphur coke and inferior raw materials, a blast furnace must resort to a very limey slag or increased slag volume in order to insure low sulphur steel-making iron. Either means low tonnage in blast furnace and high coke ratio. If the manganese in the hot metal is kept around 2 per cent, it is possible for the blast furnace man to run his iron higher in sulphur with leaner slags, increased tonnage, and reduced fuel ratio; and at the same time deliver to the open hearth, iron as low in sulphur as could be obtained with low manganese iron cast much lower in sulphur. This is borne out by the following figures of 136 tests run on high manganese irons between blast furnaces and Open Hearth No. 3 at Bethlehem, to determine the desulphurization which occurred in the pig iron transfer ladle.

The methods used were as follows: C blast furnace was run on high manganese iron with lean slags and of course high sulphur. A sample of this metal was taken from each ladle at the blast furnace and from the same ladle at the open hearth mixer. The average time between sampling at the blast furnace and the mixer was 80 minutes which is about the average time consumed in normal operation. 136 ladles of iron were thus tested. The ladles contained varied percentages of manganese and sulphur which I have divided into three groups according to manganese content as follows:—

	Per cent
First group, iron from	1.00 to 1.50 manganese
Second group, iron from	1.50 to 2.00 manganese
Third group, iron from	2.00 and above

Averages of the Results Are Given Below.

Group	No. of Tests	Per Cent Sulphur at Blast Furnace	Per Cent Manganese	Per Cent Sulphur at Mixer
1	21	0.0867	1.39	0.041
2	89	0.07	1.72	0.035
3	26	0.073	2.13	0.031

From the above it would seem, at first glance, that an average of 1.39 per cent manganese as as effective as higher manganese for desulphurization in the ladle. It will be noted that the pig iron sulphurs in the entire twenty-one heats of the first group, were relatively high, thus affording better opportunity for reduction of sulphur than was afforded in a number of casts in the second and third groups.

We found that with iron running less than 1.80 per cent manganese, it was necessary to hold longer in the ladle than with manganese over 1.80 per cent

The silicon on this iron averaged 1.15 per cent. I believe that this should be below 1 per cent since I have assumed that with normal temperatures the elimination of sulphur from pig iron in the ladle takes place under following reaction:—

Slag formed on ladles is properly MnOSiO2 (Manganese Silicate). Any excess of SiO2 forms FeOSiO2 (Iron Silicate). Manganese in connection with sulphur forms MnS which with low SiO2 is broken up to Mn and SO2, Mn going back into the metal, and the SO2 goes into the air.

With excess SiO2 we have FeOSiO2 present, MnS + FeS + MnOSiO2. FeS goes back into the metal and no reduction of sulphur takes place. In this test dolomite was used in the runner at the blast furnace, in the place of sand, in order to keep the slag as low as possible in SiO2.

With high manganese iron, elimination of sulphur also takes place in the mixer, if the SiO2 is kept low in the slag. With a ratio $\frac{SiO2}{MnO} = 0.80$ in slag, greatest removal was accomplished, but some removal takes place with $\frac{Mno}{SiO2}$ = as high as 1.20. In these tests the averag removal of sulphur in the mixer was 0.006 per cent.

The general conclusions that I have drawn from the above data, are, that it is possible for the blast furnace man with high manganese iron, to run lean slugs, maintain tonnage, and with sulphur in blast furnace iron as high as 0.1 to deliver that same iron to the open hearth furnaces through mixer, with 50 per cent of sulphur eliminated.

High Manganese Iron, in its Relation to the Operation of an Open Hearth Furnace.

The principle objections brought out against the use of high manganese iron are:

Decreased tonnage, decreased yield of ingots, scorification of furnace banks and scorification of ladle linings.

I will give the results of our experience at Open Hearth No. 3 at Bethlehem in this connection.

Tonnage—During the month of August 1920, we worked exclusively on high manganese iron. We have 50 ton furnaces and tapped 70 ton heats of ingots. Our average time of heats during this month was 10 hours and 15 minutes. The includes all the alloy grades, and is the best average time that was ever made in this shop. We feel that one of the reasons of this decrease in time of heats was the fact that a slug can be worked into shape quicker with high manganese iron than with low manganese.

Yields at Open Hearth No. 3 for the month of August 1920, according to grades, are as follows:

	Per Cent
Basic carbon high manganese	89.77
Basic carbon ordinary	90.29
Basic carbon special	89.47
Basic carbon high silicon	90.45
Basic nickel	88.38
Basic chrome	91.18
Basic nickel chrome	89.89
Basic chrome vanadium	91.64
Basic chrome molybdenum	90.22

This is better practice than we have averaged with low manganese iron, which I partially explain as follows:—

Average analysis of iron:

2.10	.029	.051	1.18
Mn.	P.	S.	Si.

which with our scrap charge would give us a charge of about 1.40 per cent manganese. The residual manganese in the bath averaged 0.34 per cent or a loss in manganese of 1.04 per cent of the weight of the chare.

Our experience with low manganese iron, running about 0.705 per cent manganese, would be a charge containing about 0.60 per cent manganese, a residual of 0.10 per cent manganese, or a loss of 0.50 per cent manganese. Therefore, the difference in manganese loss of a high manganese charge over a low manganese charge would be 1.04 per cent.

Our slag weight runs about 250 pounds slag per ton of charge. With normal slag on low manganese iron, this slag contains about 16 per cent of FeO or 12 per cent, which is 1.34 per cent of the metallic charge.

The slag on high manganese iron charges, as will be shown later, shows an average of 9 per cent FeO or 7 per cent Fe which is 0.69 per cent of the metallic weight of charge. This gives the FeO loss in slag 0.69 per cent on high manganese iron against 1.34 per cent low manganese iron or a saving of 0.65 per cent of iron, which more than equalizes the 0.54 per cent loss in manganese due to the use of high manganese iron.

Scorification of Furnace Bottoms.

I can find no explanation as to why high manganese iron should be harder on furnace bottoms than low manganese iron. In fact our experience has been, if anything, the other way. During this same month of August, we averaged 11 minutes bottom delay per heat which is lower than usual. MnO being a base should not affect a basic bottom.

Ladle Linings.

Our experience with ladle linings shows nothing detrimental in the use of high manganese iron. Our average for the month of August, of 18 heats per ladle, compares favorably with ordinary practice. We used

a 90 ton ladle for a 70 ton heat, giving a large volume of slag; with slow pouring through 1½ inch nozzles. Also, we box-pour, which necessitates steel and slag.

Effect of High Manganese Iron on Quality of Steel Produced.

Sulphur and oxygen are the cause of considerable worry to those whose task it is to convert the ingot to the finished product. The effect of manganese on sulphur and oxygen is believed to be as follows:

Sulphur—Iron combines easily with sulphur and in certain associations at certain temperatures is capable of taking it up from otherwise stable compounds. Among others, it decomposes sulphate of lime (CaSo4) according to the equation:

$$CaSo4 + 4Fe = FeS + CaO + 3FeO.$$

The iron sulphide goes into the metal. From this it is seen that even though we start with a low sulphur charge and are compelled to use high sulphur fuel, the sulphur may get into the bath in the fol- from the furnace, with the waste gases, and the slag is robbed of its sulphur content.

Averages are as follows:

Iron with manganese 0.75 per cent to 1 per cent, giving residual manganese of below 0.20 per cent the finished sulphur in heat shows 0.046 per cent.

Iron with manganese 1 per cent to 1.50 per cent giving 0.20 per cent to 0.25 per cent residual manganese, the finished sulphur in heat shows 0.043 per cent.

Iron with manganese 1.50 per cent to 2 per cent giving 0.25 per cent to 0.30 per cent residual manganese, the finished sulphur in heat 0.041 per cent.

Iron with manganese above 2 per cent giving above 0.20 per cent residual manganese the finished sulphur in heat shows .038 per cent.

The sulphur in the charge was increased with the manganese in the iron rather than decreased:

Charge of 0.75 per cent to 1.00 per cent manganese averaged 0.052 per cent sulphur.

Charge of 1.00 per cent to 1.50 per cent manganese averaged 0.053 per cent sulphur.

Charge of 1.50 per cent to 2.00 per cent manganese averaged 0.055 per cent sulphur.

Charge of above 2.00 per cent manganese averaged 0.061 per cent sulphur.

Same fuel was used on all heats.

With the nickelferous irons used for making nickel steel:

A 0.0345 per cent sulphur iron containing 0.66 per cent manganese gave 0.0385 per cent sulphur in the steel; a 0.0395 per cent sulphur iron containing 2.35 per cent manganese gave 0.029 per cent sulphur in the steel. Outside of the pig iron other elements were the same.

An interesting experiment was conducted in Bethlehem two weeks ago in connection with the removal of sulphur by means of manganese. Cast A2332 analyzing at blast furnace Mn 1.92, P .120, S .226, Si 0.65 was used directly on heats B55676 and C52237; the residual manganese in these heats was 0.31 per cent and 0.33 per cent respectively; the sulphurs on the finished heats were 0.029 per cent and 0.030 per cent. At the same time cast B4004 analyzing Mn 0.90, P 0.98, S .120 and Si 0.68 was used on heat B55688 and the finished sulphur showed 0.077 per cent. All three heats were worked as nearly alike as possible in the furnace, using the same kind of fuel, scrap, limestone, charge, etc. No time was lost working down sulphur in either case.

From the above results I have concluded that manganese introduced in the pig iron will reduce sulphur in the open hearth charge.

Oxygen.

Oxygen is contained in all classes of steel but only in very minute amounts. The estimation by analysis of the amount present is accompanied by very great difficulties. In spite of the fact that the amount of oxygen going in the steel is in very small ratio to the total weight, we can daily observe that iron takes up oxygen and that large amounts of reducing agents are not capable of completely hindering its entry. Carbon, phosphorus and silicon, for example, act imperfectly in a basic furnace to take up oxygen.

According to the best evidence, the first indication of red-shortness in steel is noticeable with 0.01 per cent oxygen, while a content of 0.05 per cent oxygen renders steel unusable.

According to Dickman; red-shortness due to oxygen cannot be offset by carbon, phosphorus or silicon, but can be very much reduced by means of manganese, which, although it does not effect complete removal, must be regarded as the best destructive agent of the ferrous oxide dissolved in the iron. We can then use manganese as a preventative agent against red-shortness by means of additions to the charge. This is best accomplished by the use of high manganese iron.

Dickman also claims, and this is borne out by our practice, that oxygen will not be found in steel in note-worthy quantities so long as the residual manganese remains sufficiently high (0.30 per cent). The reason for this is as follows:

In acid steel manufacture, a great deal has been said in the past few years about the impregnation of both with silicon from the slag and furnace bottom; and I think it has been generally agreed that an acid heat, to impregnate any large amount of silica must be pretty free from oxides. The same may be said about reversal of manganese from slag to metal in a basic furnace. When this takes place, the heat must be pretty well cleared up and the slag and metal must be nearly free from FeO.

Slag analyses were taken from heat B55699 at the same time as the tests for residual manganese; with the following results:

Manganese:

	Per Cent
In first test	0.20
In second test (½ hour later)	0.32

Slag Analysis:

	SiO2	CaO	MgO	FeO	MnO	P2O5	Sul.
First test	22.15	48.28	5.32	10.55	5.65	1.43	.235
Second test	24.93	48.81	7.70	7.09	3.95	1.45	.125

The decrease in MnO shows a return of manganese to metal from slag; a corresponding decrease of FeO; also a decrease of sulphur in slag due to the MnS being broken up and the Mn returning to the metal. With iron oxides as low as this in basic open hearth slag, we would not expect much oxygen to be found in the steel.

Remodeled Blast Furnace at Ironton, Ohio

The Belfast Iron Works Company Has Successfully Blown in The Blast Furnace After It Has Been Down for One Year for Improvements—Entire Character of the Plant Has Been Changed.

By F. H. WILLCOX.

AFTER being out of blast for one year for improvements at the plant, the furnace of the Belfont Iron Works Company, Ironton, O., was successfully blown in on August 31, 1920.

The work carried through on this blast furnace entirely changed the character of the plant. The original furnace was 75 ft. high with a 10 ft. hearth, 16 ft. bosh and 10 ft. stock line, and maintained an average daily production of 150 tons. Under the management of Karl Steinbacher, superintendent of the furnace plant, the old furnace had stayed in blast on one lining for eight years and five months, a record on lining that is very noteworthy. The furnace was hand-filled, coke being for the most part unloaded from box cars and hauled a matter of 250 feet to the elevators, while the ore and stone was dumped from trestles, loaded into buggies and then hauled to the elevators, the length of haul varying from 50 to 250 feet. All cinder was run on the bank into runners, from whence it was forked by manual labor into railroad cars adjacent to the bank or into carts by means of which the slag was hauled and dumped on adjacent company property.

The furnace was served by four 16x60 ft. Whitwell stoves, the shells and bottoms of which were badly rusted and thin, and in some cases sheared to an extent that made their further use impossible. The domes had been renewed on three of the stoves. There was an auxiliary 20x80 ft. McClure stove which had been erected in 1917 but which had never been connected onto the blast or gas main system. Both stoves and boilers were served by an underground gas main and both stoves and boilers connected with the draft stack by means of underground flues.

The boiler equipment consisted of six double-flue boilers suitable for 100 lbs. steam pressure. The blowing equipment consisted of two Totten & Co. Pittsburgh Blowing Engines, in service since 1878, incapable of blowing much more than 7 lbs. blast pressure. The entire plant was run non-condensing.

In addition to the McClure stove, which was erected at the end of the row of four Whitwell stoves, the company had on hand, unerected, a General Electric turbo blower of 22,000 cu. ft. capacity, a Wheeler condenser and Engineering Company barometric condenser, complete with exhaust piping purchased for installation with the blower, and two Wheeler motor driven centrifugal condenser pumps.

At a somewhat earlier date the company had put in a notable improvement in pig iron handling in the shape of a cast house crane equipped with magnet for loading pig iron from beds into cars and onto pig iron wharf. They had also installed a permanent steel trestle which connected with the Norfolk & Western Railroad and led up to the space between the furnace plant and the river bank, utilized for cinder bank.

The blast furnace was blown out on June 11, 1919, and work of dismantling was immediately started. The shell of the furnace was in excellent condition as were the foundation, columns, and column base plate. After the lining was removed and the iron and steel work of the hearth and bosh was dismantled, it was found that the furnace shell and mantle required no leveling as they were substantially correct.

Both on account of the lightness of construction of bosh bands, tuyere breast reinforcement and hearth jacket, and on account of the alterations in lines of the furnace, entirely new iron and steel work was placed beneath the bosh. New 1¼ inch bosh bands were placed, these bands being rigidly supported by cast steel bosh band supports to prevent slipping of the bands. A new tuyere breast was built, consisting of a continuous ring of 1 inch steel plate with openings for eight tuyere coolers and tuyere breast plates; a new cast iron hearth jacket with cooling pipe cast in was used, this jacket being 6" thick, reinforced with three 1¼" encircling bands. The hearth jacket segments were also bolted together. This hearth jacket extends five feet below the bottom of the iron notch and is bricked up solidly about the outside, only a small run-off trough for occasional waste water being provided. All water connections on hearth, tuyere breast and hearth jacket discharge into the water trough at the mantle.

A small salamander was removed and the bottom laid up with five courses of standard 18 x 9 x 4½" bottom block.

The cubical capacity of the furnace was slightly increased insofar as this could be done without changing the mantle ring or column base plate ring. The bosh was lowered and made steeper, the batter of the inwall was increased, the hearth and bosh diameters were increased, thus giving a total cubical capacity of furnace of 9,280 feet. From the center line of tuyeres to within 2 feet of bell there are 8,580 cubic feet. This is the Southern Pig Iron Association's rating basis, and on their 60 pounds of coke per cubic foot capacity figure, this furnace should be capable of burning 515,000 pounds of coke per day, corresponding to a pig iron production of approximately 250 tons.

The lining of this furnace was furnished by the Harbison-Walker Refractories Company, the same brand being used as that which gave such a remarkable record on the previous blast campaign.

All of the old Whitwell stoves were dismantled and sold for scrap, with the exception of one, part of the shell of which was in good condition. This stove had the bottom course taken out, this being the weakest part of the stove. It was lowered and moved over adjacent to the furnace and converted into a dust catcher.

In the place of the four old stoves there were erected two new Brassert-Jones 2-pass hot blast stoves, 20 x 80 feet, having a combined heating surface of 120,000 square feet. These, in conjunction with the existing McClure stove, gave a total of 158,000 square feet of heating surface. Oak Hill Fire Brick Company's Cambria Stove

Brick was used. An entirely new bustle pipe and hot blast main was installed between stoves and furnace.

Stoves were equipped with mushroom type hot blast valves, Universal stove burners and Weinel chimney valves. The existing stack which originally served both stoves and boilers was made use of in the remodeling work, the two new Brassert-Jones stoves being connected to the stack by means of the new underground brick-lined concrete flue integral with the stove foundation.

The gas main system is comprised in the new dust catcher converted from one of the old stoves from whence the gas is led direct to the boilers by means of the new overhead gas main. The gas for the stoves is taken from the stove flue and stack materially help draft conditions at the stoves, the stack temperature of the new stoves being so low as to have probably occasioned difficulty with low draft had the existing stack been connected to the stoves only.

The boilers are all provided with Birkholz-Terbeck Gas Burners equipped with butterfly regulating valves and positive shut-off valve, and have standard piping equipment throughout. The boiler blow-off lines have double blow-off valves and all blow-off valves discharge through a common header into a blow-off well. This blow-off well in turn connects to the sewer carrying waste water from the gas washer discharge. Waste water from

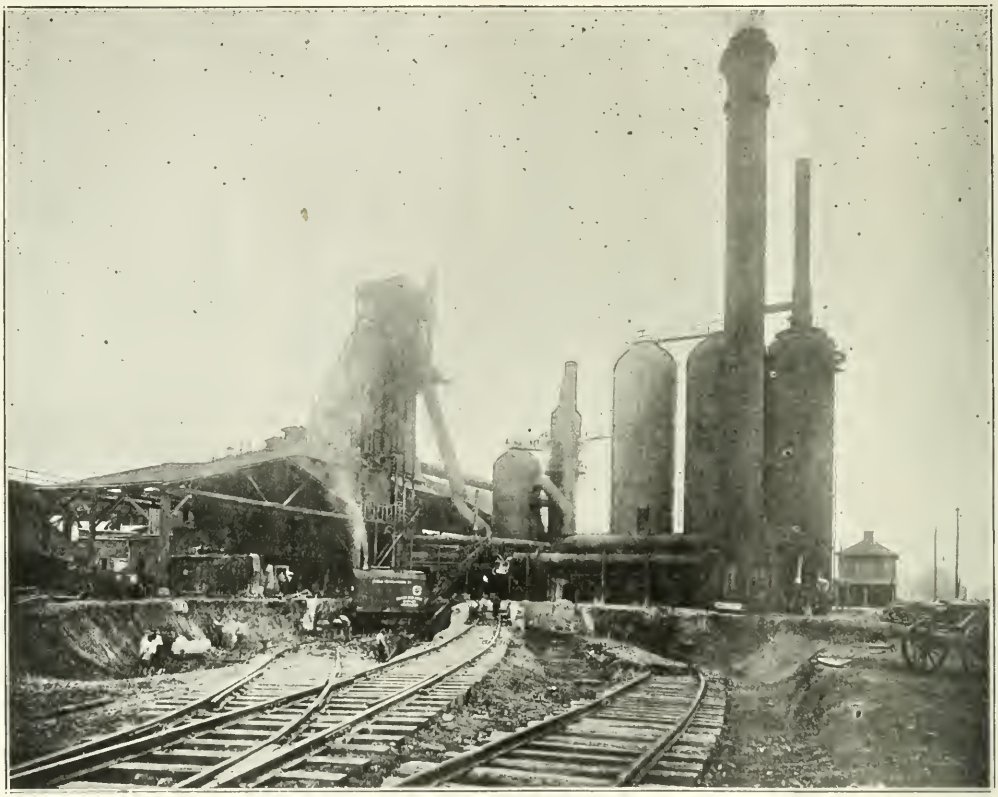


Fig. 1—Showing cinder pit, stoves, gas cleaning system and furnace.

the boiler gas main and led to a 10 foot Brassert washer, and by means of a new overhead gas main to the stoves. A by-pass is provided between dust catcher and stove gas main.

The new boiler plant consists of seven Stirling water tube boilers, a total capacity of 2100 bhp being provided. Four of the boilers have their breeching connection adjacent to the stove flue and discharge into it, while the other three boilers have independent stacks. This arrangement is found to be most beneficial for not only was the cost of new stacks saved but the relatively higher temperature of gases from the boilers passing into the hot blast stoves is also taken care of through the same sewer, as is surface drainage about stoves, boilers and town side of plant.

From the new stoves a new cold blast main was put in, together with 20-inch by-pass valve back to the new turbo blower, with an auxiliary blast connection to the old reciprocating blowers, which are kept in position and connected to steam supply for use in an emergency. The cold blast line is equipped with safety relief valves, Pratt & Cady cold blast valve, and has provision for connection of steam lines for use in emergency.

As the foundation for the air end of the blower had

already been placed in the existing power house, it was decided to utilize this location. The house was therefore extended, foundations for the steam end placed and turbo blower set in position. The house was also extended down river, in which extension was placed a new Otis steam hoist, two motor driven Wheeler condenser pumps and the steam cylinders for operating the blast furnace

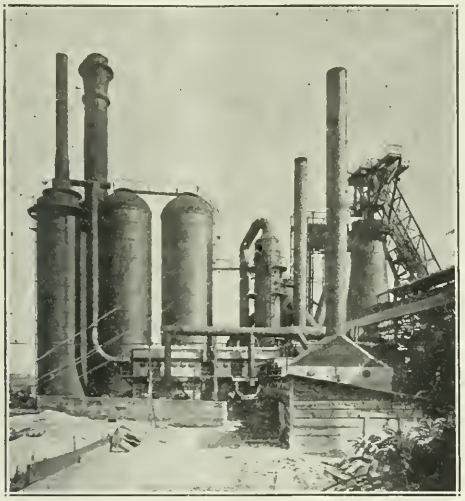


Fig. 2—Showing boilers, stoves, gas cleaner and furnace.

bells. An extension was also made in existing power house bay, in which was placed a new 125 kw Ridgway reciprocating dc generator. This was installed to take care of increased electrical requirements in the new Wheeler condenser, pumps and new scale car. This is supplemented by the existing 75 kw Ridgway generator which was purchased before the reconstruction period to take care of the crane and lighting service.

The old water system consisted of two Fairbanks-Morse reciprocating pumps mounted on incline at river, which were used for supplying all the water for the plant. These originally pumped to small overhead tanks whence the water ran to the bosh and back into an underground cistern. From this cistern water was repumped back into the tank by means of McGowan reciprocating pumps. For boiler feed water service there were three Worthington pumps already at the plant in excellent condition and capable of pumping against 175 lb. pressure.

In laying out the new water system provision had to be made to take care of materially increased amounts of water inasmuch as the condenser required an additional 1,000 gallons and the washer an additional 500 gallons over and above the former requirements. Moreover, due to the redesign of the furnace more cooling water connections were incorporated in the bosh piping, this also increasing the amount of water by perhaps 300 gallons per minute.

In laying out the new water system the Fairbanks-Morse pumps originally on the river bank incline were installed in the pump house which was made integral with existing power house. These were supplemented by the McGowan pumps originally in use for recirculating the water from the cistern to the tanks. Two new Worthington 2,000 gallon centrifugal pumps, driven by General Electric single stage steam turbines, were installed on a new incline. These pumps deliver to a single 10 inch line running up the incline and this line is provided with three discharges, one to a double compartment reservoir, one to the furnace bosh and one to the condenser. The suction of the Wheeler condenser pump leads to each compartment of the reservoir and the discharge of these pumps was connected up so that the pumps can serve either the condenser or the furnace bosh. By means of a by-pass they can also serve the line leading to the gas washer, stoves and general wash-up hose connections.

The suction of the reciprocating Fairbanks-Morse, Worthington and McGowan pumps was also led to the double compartment reservoir with an auxiliary suction in the condenser hot well. The discharge from these pumps leads primarily to the gas washer, stoves and wash-up hose connections but by means of auxiliary connections these pumps may also serve the furnace bosh. It will be seen that the water system provided a most flexible system. In ordinary operation the river pumps discharge 1,000 gallons per minute direct to the blower condenser, pumping at a head of approximately 120 feet from river to condenser inlet. The condenser discharge water runs by means of a weir back into one of the two compartments of the reservoir, from which the boiler feed pumps and the gas washer and general service water reciprocating pumps draw their supply. The other 1,000 gallons from the river pumps over and above the requirements of the condenser are discharged into the second

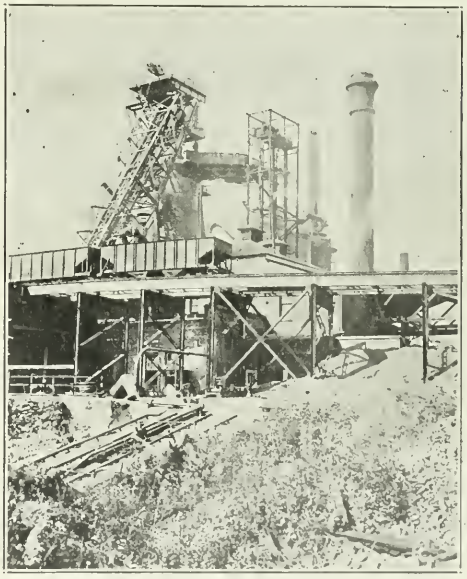


Fig. 3—Showing bins and trestle approach, skip incline and power house.

compartment of the reservoir; from this compartment the Wheeler pumps draw their supply and pump direct to blast furnace bosh. The blast furnace bosh water is led back and discharges into the same reservoir that the condenser hot well water flows into. By means of a weir between the two compartments, should the water in the

reservoir from which the furnace bosh water is pulled, become low, the large surplus of water from the other reservoir will flow into it, thus maintaining the level. Normally there is a substantial flow of cold water in the opposite direction.

Exhaust steam from the reciprocating pumps is led through a feed water heater. The generators are connected up so that their discharge can be led through to the feed water heater or to the condenser. An entire new steam line system was installed adequate for 160 pounds pressure.

The present method of handling iron was left unaltered but to take care of slag two dry cinder pits were installed with a common track between them. These pits are served by a Marion Model No. 36 revolving steam shovel, mounted on railway wheels and equipped with standard 20 foot boom and 1½ cubic yard dipper. On account of the certainty of a considerable surplus of steam and at the suggestion of Mr. Steinbacher, a steam line was led from the Stirling boilers to the various working positions of the shovel and steam is furnished the engine from the gas fired boilers through flexible hose, the boiler furnished with the engine being used as a receiver separator.

With the exception of the new steel trestle previously mentioned, all the existing wooden trestles were scrapped. From the end of the steel trestle an extension was made leading to a set of new steel bins and thence to a stocking trestle; both bins and stocking trestle being double tracked. The bin equipment consists of one coke bin, chuting coke direct to skip cars. The chutes are equipped with Haven type coke screens, each chute discharging into a common header that leads the coke braize to a small auxiliary skip at the bottom of the skip pit. The coke bin has a capacity of 200 tons of coke. There are two limestone bins having a total capacity of 225 tons of stone, and six ore bins having a total capacity of 1,000 tons of ore. The bins were purposely made of ample capacity so that minimum labor would be required. For a 250-ton pig iron production under established operating conditions no labor will be required at the bins on night turns.

For unloading material and getting ore and stone into the bins there is provided an Orton & Steinbrenner 30-ton 8-wheel steam operated standard gauge locomotive crane having 50 ft. boom, 1½ cu. yd. extra heavy ore bucket. This crane works on an 80 ft. track radius, has 19,000 lb. capacity at 50 ft. radius with outriggers in place, and has 9,700 lb. capacity at 50 ft. radius without outriggers.

The stock yard is equipped with Atlas 100 cu. ft. capacity single hopper scale car.

The old elevator was left in position to serve as a passenger and freight elevator for access to the top. A new cantilever type double track skip incline was installed at the furnace. The skip cars have a capacity of 2,250 lbs. of coke each. The old single bell top was replaced with a standard Brassert type double-bell top.

The entire plant, inclusive of ore and limestone stocking room, skip pit, pig iron handling, power house and stove and boiler location, is comprised in 4¼ acres.

The outstanding improvements consist in the enlargement of the furnace from 150 to 250 tons daily capacity; the provision of adequate blowing and hot blast stove equipment to realize this capacity; the provision of stocking and charging equipment to enable stock to be fed to the furnace, with marked economy in labor, fast enough to maintain this capacity; the provision of mechanical slag pit arrangement to take the place of hand forking of cinder with its attendant large labor force; the provision of a power house in which is concentrated all power generation and handling inclusive of reciprocating and condenser pumps, generators, blowers, skip hoist engine and steam bell operating cylinders; and finally, the cutting of a preexisting labor force of approximately 120 men to a present labor force of approximately 80.

Freyn, Brassert & Co. were Consulting and Supervising Engineers on this work. In coöperation with S. G. Gilfillan, president, and Kard Steinbacher, superintendent, of the Belfont Iron Works Company, a construction force was organized which was placed under the joint supervision of Mr. Steinbacher and W. I. Cool, Resident Engineer of Freyn, Brassert & Co. This construction organization was made up of the Belfont Iron Works Company's operating force who took care of certain dismantling and fitting-up jobs; Hibben & Co., who fabricated and erected all iron and steel work comprised in the furnace below the mantle, new bustle pipe and hot blast main, new stoves and cold blast and gas mains, including the dust catcher and gas washer; the Mt. Vernon Bridge Company, who fabricated and erected the new bins and trestle, skip incline and furnace top; F. B. Davies, who had all excavation and concrete work; Harry Wileman who had the general contract for all brickwork in the stoves, furnace, setting of boilers and extension of power house; Charles Bick, who had in charge the erection of the Stirling boilers; and the Pittsburgh Piping & Equipment Co. who put in the new steam and water line systems and also erected the condenser and exhaust piping.

APPEAL FOR DEVELOPMENT OF FOREIGN TRADE.

In addressing the seventh annual meeting of the National Foreign Trade Council, James A. Farrell, president of the United States Steel Corporation and chairman of the council, urged the necessity for developing foreign markets if the present productive capacity of this country is to be maintained.

"The foreign trade of the United States, in common with domestic business, is suffering from the general contraction of credit," he declared. "American exporters in many cases have been unable to finance an extension of their existing trade. In other cases they have been unable to grant to foreign customers the credit necessary to insure continued foreign purchases. Furthermore, the situation has been aggravated by the low purchasing power of many European nations, and by the frequent disturbances in transportation facilities.

"Under these conditions some of our manufacturers have been forced to diminish or discontinue their activities in foreign fields. But it is inconceivable that such a lessening of our foreign trade interests should be suffered to continue longer than is absolutely necessary, or should be allowed to deter American manufacturers from making foreign trade a permanent and integral part of their business policy.

"In every business there is a part of the production, roughly estimated at the last 20 per cent. which cannot remain unsold if the first 80 per cent of the sales are to prove profitable. Remove this last 20 per cent and the whole operation will cease to show a profit. So it is with the present productive capacity of the United States; a certain volume of foreign sales must be maintained or the industry of the country will suffer throughout."

Reactions in Certain Steels at 930° C.

Reasons Why Different Investigators Working on Same Kind of Steel, With Apparently the Same Heat Treatment, Do Not Get the Same Results, Due to Influence of Increased Temperature.

By E. D. CAMPBELL and B. A. SOULE,
University of Michigan.

IT has been recognized for many years that the physical properties of steel are primarily dependent upon chemical composition. The dependence of such properties as electrical and thermal resistivity, thermo-electromotive potential, as well as magnetic properties, on the chemical constitution, has been more fully appreciated during the past 25 years than ever before. It is now very generally recognized that changes in physical properties, such as elastic limit and hardness induced by cold working, are not accompanied by any material change in electrical resistivity or thermo-electromotive potential. These two latter properties are directly dependent on the concentration and degree of dissociation of the carbides or other solutes in solution, and consequently variations in these properties may be used as means of detecting or determining changes which must have taken place in atomic relations between the solutes and solvent. The rate at which reactions take place in recently hardened steels at room temperature and at 100 degrees C. composed the subject-matter of an article presented to the Institute in 1918.* The results obtained at that time show very strikingly the great influence of even a comparatively slight increase of temperature on the rate of reaction, since at 100 degrees C. there was a greater change in specific resistance in 12 hours than there was in two years at room temperature.

The object of the present investigation was to determine whether when a bar of steel 6 millimetres square by 15 centimeters long was hardened by quickly plunging it into ice water there would be a detectable difference in chemical constitution between the two ends of the bar. Such a bar may be considered as made up of a number of sections, No. 1 being that which first touches the water. In such a case the instant section 1 enters the water heat will begin to flow from the furthest section towards it, so that when the furthest section is below the surface it will be cooled more rapidly than the opposite end, since heat is lost not only to the surrounding medium but also by metallic conduction toward section 1.

Bars of these steels 6 millimeters square and 15 centimeters long were suspended in an electrically heated furnace which had been brought to the temperature from which the bars were to be quenched. The furnace was so designed that the bars might be maintained at a given temperature for any desired length of time without any oxidation. The time required to transfer a bar from the furnace to the quenching bath was reduced to about one second. The bars were kept in the furnace one hour in order to be sure that they were at the same temperature as the furnace, the temperature being measured by means of a platinum platinum-rhodium thermocouple, the head of which was within a few millimeters of the bars under treatment. Quenching was effected in a large volume of water maintained below 10 degrees C. by means of crushed ice. The time required for each bar to lose all red color after immersion did not exceed one second, while within five or six seconds it had cooled to bath temperature.

As it was not practicable to measure the electrical resistance of the end of a bar, resort was had to measurements of the thermo-electromotive potential of the solutes by measuring the potential when the hardened bars were opposed to bars of very pure electrolytic iron.

Five steels were selected for the work.

"A" is a hypereutectoid nearly pure iron carbon alloy made by carburizing ingot iron. This steel was selected in order to eliminate as far as possible the influence of elements other than carbon.

"B" is a high silicon transformer steel.

"C" is a basic open hearth 5 per cent nickel steel.

"D" is a commercial manganese steel.

"E" is a hypoeutectoid manganese steel resulting from the decarburization by means of hydrogen of steel "D."

The composition of the five steels is given in Table 1.

Table 1—Percentage Composition of Steels.

A	1.184	0.016	0.005	0.018	...	...
B	0.094	0.122	0.03	0.025	3.649	...
C	0.182	0.493	0.010	0.030	0.267	5.00
D	1.150	11.57	0.055	0.023	0.25	...
E	0.133	11.57	0.055	0.026	0.25	...

The electrolytic iron used was furnished the authors through the courtesy of Dr. T. D. Yensen, who had prepared a number of small ingots by melting *in vacuo* in crucibles of pure fused MgO, selected pieces of electrolytic iron deposited when using American ingot iron as an anode. From one of these small ingots a bar about 55 centimeters long and nearly 1 centimeter square was forged. Three pieces, 15 centimeters each in length, were cut from the long bar and annealed by heating *in vacuo* to 958 degrees C., followed by slow cooling in the furnace. From these annealed bars the 6 millimeters square samples used in the experimental work were machined.

The method of measuring the potential developed for a temperature gradient of 1 degree at sections 1 to 15 of the different hardened steels (fifteen sections being the number into which the bar was regarded as being divided) was essentially similar to the method used in work of this kind previously described,† but somewhat modified with view to increasing the accuracy of the determinations and eliminating the slight electromotive force occasionally arising from direct contact of water with the steel at the cold ends of the system.

The set-up for measurement consisted of three of the heat-treated bars held together at their ends with small pure iron clamps, so that they could be adjusted to any desired angle and a similar compound bar made up of three pieces of electrolytic iron. These compound bars

*Journal of the Iron and Steel Institute, 1918, No. II, p. 421.

Paper read before the British Iron and Steel Institute, autumn meeting.

†Journal of the Iron and Steel Institute, 1915, No. II, p. 268; ibid., 1917, No. II, p. 251.

were fastened together at one end by means of a clamp like the others. The compound bar was so shaped that this hot junction was immersed about 8 centimeters below the surface of a gas-heated oil bath, provided with a motor-driven stirrer to insure uniformity of the temperature. This was determined by means of a long mercury thermometer graduated in tenths of a degree, the bulb being placed in close proximity with the hot junction. The thermometer used was standardized by comparison with a similar one having a Bureau of Standards certificate, and all necessary corrections were applied to each reading in order to determine the actual bath temperature. To the outer ends of the system of six bars, resembling roughly in form a block M, lead wires of annealed ingot iron were clamped, their opposite ends being connected with the potentiometer by means of copper leads, these two connections being placed close together in a small bottle containing enough oil to cover them and thus insure uniformity of the contacts at this point. The two vertical bars with their leads were placed in test-tubes filled to a depth of 6 or 7 centimeters with some of the transformer oil used in the oil bath. The test-tubes were placed in large earthenware cups filled with crushed ice and provided with a small hole in the bottom to allow escape of water. Measurements made with a small thermometer, so placed that the bulb was inside the clamp and against the lower end of the bar, showed that when equilibrium was established the cold end of the bars stood at 1.8 degrees C. This was therefore adopted as the cold junction temperature. A temperature gradient of as nearly as possible 50 degrees was employed—that is, the thermometer at the hot junction stood at about 52 degrees C. The thermo-electromotive potentials were measured by means of a Leeds & Northrup precision potentiometer, a Weston cell with Bureau of Standards certificate being used in balancing. This apparatus is graduated directly to 0.5 microvolt, thus tenths may be quite accurately estimated. An experimental error of 1 microvolt when measuring potential with a total temperature gradient of 50 degrees would therefore introduce an error of only 0.02 microvolt when the potentials reported, as is done in Table 2, are reduced to a gradient of 1 degree.

Measurements of thermo-electromotive potential were made using three freshly quenched bars of each of the five steels, the first set of measurements being made with the bar which was in the oil bath, so placed that section 1 was in contact with the electrolytic iron, thus constituting the hot junction. The second set of measurements on the freshly quenched bars was made with the position of the bar in the oil-bath reversed—that is, with section 15 as part of the hot junction. When all measurements on the freshly quenched bars had been completed, all the hardened bars were tempered at a temperature varying from 110 degrees to 115 degrees C. by placing them for 24 hours in an electrically heated oven. After tempering the bars two more sets of measurements were made under the same conditions as those used in examining them when freshly quenched.

The results of these measurements are summarized in Table 2, in which column 1 gives the steel; columns 2 and 3 the thermo-electromotive potential of sections 1 and 15 respectively for a temperature gradient of 1 degree. Column 4 shows the difference between sections 1 and 15 of the freshly quenched metal. Columns 5 and 6 give the potentials due to a gradient of 1 degree for sections 1 and 15 after tempering, the difference between these latter measurements being shown in column 7. The change in thermo-electromotive potential for a temperature gradient of 1 degree, due to the tempering, is shown in columns 8 and 9.

An examination of the figures given in Table 2 would lead to the following conclusions:

1. The difference in the rate of cooling of the two ends of a bar produces changes in chemical constitution which result in differences in thermo-electromotive potential much in excess of anything attributable to experimental error.

2. In all the freshly quenched steels, Section 15, on account of the more rapid rate of cooling, has a higher thermo-electromotive potential than Section 1.

3. In the carbon steel "A" the difference in potential at the opposite ends of the bar would indicate a difference in chemical constitution approximately equal to 8 per cent of that due to tempering at 110 degrees C. and about 3 per cent of that due to the total carbide concentration.

4. In steels like B, C, D, and E, having a third element whose thermo-electromotive potential is higher than that which would be due to carbides alone, the effect of precipitating carbides by tempering at 110 degrees C. is to increase the thermo-electromotive potential. This increase is in accord with the principle advanced in a former paper dealing with this point.*

In complex steels containing two or more elments other than carbon, such as chromium, tungsten, or molybdenum, changes in chemical constitution due to differences in rate of cooling do not manifest themselves as simply as they do in the case of steels investigated.

The rapidity with which reactions take place in steel at high temperatures producing changes in chemical constitution which affect both electrical resistivity and thermo-electromotive potential, makes it easy to understand why different investigators working on presumably the same kind of steel with apparently the same heat treatment, may not agree very closely on the values reported.

*Journal of the Iron and Steel Institute, 1917, No. 2, p. 251.

Table 2.

Steel	T.E.M.P. in Microvolts for 1° Gradient of Freshly Quenched Bars		Dif.	T.E.M.P. in Microvolts for 1° Gradient of Tempered Bars		Dif.	Changes due to Tempering	
	Sect. 1	Sect. 15		Sect. 1	Sect. 15		Sect. 1	Sect. 15
A	13.50	13.85	0.35	8.65	9.05	0.40	—4.85	—4.80
B	22.80	22.95	0.15	23.35	23.35	0.00	+0.55	+0.40
C	16.50	16.60	0.10	16.60	16.70	0.10	+0.10	+0.10
D	21.60	22.20	0.60	22.30	22.55	0.25	+0.70	+0.35
E	13.10	13.40	0.30	13.30	13.45	0.15	+0.20	+0.05

Uniflow Steam Engine in England

Principle and Special Features—Advantages of the Uniflow Engine—Its Flexibility, Speed Control and Upkeep—Details of Design, Including a Brief History of the Invention.

By T. B. PERRY.

HAVING regard to the high price of all classes of fuel at the present time and the consequent necessity of reducing consumption to a minimum, it is thought that a short paper on the history, principle of working, and details of construction of the uniflow engine, the latest development of the reciprocating steam engine, may be of interest.

History.

The uniflow engine was invented in this country in 1885 by T. J. Todd. Quoting from the specification, the object of the invention was "to produce a double-acting steam engine which shall work more efficiently, which shall produce and maintain within itself an improved graduation of temperature extending from each of its two hot inlets to its common central cold outlet, which shall cause less condensation of the entering steam, and which shall work with greater economy than has hitherto been the case." The invention is described as follows: "In the first place I take a double-acting steam engine cylinder of that type which has one or more outlet openings placed at or near its longitudinal center, and which has also a piston so proportioned in length and which piston is also fitted in some cases with self-contained internal escape ports, and which piston is so worked, that it, by and of itself, forms the release valve, for releasing the waste steam through the central escape outlet or outlets near the end of each single stroke, and which piston also closes the central escape outlet or outlets at all other parts of each single stroke. In such double-acting steam engine cylinders it is, therefore, the piston itself which forms the escape valve and which releases the waste steam automatically near the end of each single stroke, and as, in this class of double-acting steam engine cylinders, the waste steam can only be released near the termination of each single stroke, I will herein afterwards, in order to avoid repetition, call and designate such double-actng steam engine cylinders 'terminal exhaust cylinders.'"

The inventor's description will be easily understood by reference to Fig. 1, which shows the latest development of the invention. Although the inventor seems to have understood the advantages of the arrangement, they were not generally recognized at the time, and the invention remained undeveloped until 1908 when Dr. Stumpf, of Charlottenberg University, took it in hand and devised a valve gear specially suited to the idiosyncrasies of the engine. Manufacture was commenced at once by the Ersten Brunner Maschinenfabrik, of Brunn, and their example was soon followed by other continental, and by several English, firms.

Before the outbreak of the war, several hundred engines had been built and set to work for driving generators, fans and mills; for winding, for propelling ships and locomotives, one of the last-mentioned having been fitted to a goods locomotive on the North Eastern Railway in England in 1913. The largest engine built up to 1914 was a mill engine for a normal load of 4,000 hp, a maximum continuous load of 6,000 hp, and an emergency load of 8,000 hp. This engine had a single cylinder 1,700 mm. diameter, 1,400 mm. stroke, and ran at a speed of 120 rpm.

Paper read before the Institution of Mechanical Engineers, England.

Principle and Special Features.

The principle, as its name implies, is "one flow" for the steam, that is, from the hot inlet ends to the cool exhaust center. The principal difference between the uniflow and the ordinary steam engine cylinder is in the position of the exhaust ports, the length of the piston, and its use as an exhaust valve and resulting compression.

The length of the exhaust ports is usually 10 per cent and the length of the piston 90 per cent of the stroke. The clearance volume, owing to the absence of exhaust valves and chambers to contain them, can easily be reduced to about two per cent of the piston's displacement. The compression ratio is, therefore, about 1.46. Under these conditions a good vaccum is necessary to prevent an excessive rise in the compression pressure. To obtain this, the condenser is usually placed immediately below the cylinder, and the exhaust ports practically unlimited in area by structural considerations, are made large enough to offer only a negligible resistance to the passage of the steam. Relief valves are provided in case the compression pressure should increase excessively through leakage past the admission valves or a fall in the vacuum. In some cases a feed-water heater is interposed between the cylinder and the condenser.

In cases where it is necessary to change over from condensing to non-condensing, it has been usual to provide an additional clearance space in each cylinder-cover communicating with the cylinder through a valve which is closed when working condensing. This provision, however, is only suitable for temporary non-condensing, working as the enlarged clearance space and surface are inimical to economy. The best uniflow engines are not fitted with an arrangement by which they can work economically, non-condensing, as the same small clearance space and surface is maintained, whether working condensing or non-condensing. In locomotive engines of the uniflow type special pistons have been used to give sufficient clearance space.

Another peculiarity of the uniflow engine is the early cut-off required to obtain a high ratio of expansion in a single cylinder. With 170 lb. pressure, eight per cent to 10 per cent cut-off is required for full load. For cutting off so early a trip-gear is unsuitable, and a powerful and highly sensitive governor is necessary to control the positive valve-gear needed. The early cut-off in a cylinder large enough to give the required ratio of expansion implies a high initial load upon the piston, and consequently heavy working parts. The

weight of these parts, however, is not without advantage, inasmuch as their inertia reduces the stresses on them and tends to equalize the turning effort throughout the revolution.

Advantages of the Uniflow Engine.

1. Economy.—The results of tests for steam consumption show that, with 180 lb. boiler pressure and 200 degrees F. superheat, consumptions of 10.5 lb. and 10 lb. per indicated horsepower hour can be obtained at full load from engines developing 500 ihp and 1,500 ihp respectively. These low rates of consumption are due mainly to reduction of cylinder condensation resulting from the high temperature of the cylinder-ends, the position of the exhaust ports, the reduction of clearance surface and volume, and the high compression. The temperature of the cylinder metal varies from point to point along the bore, from the hot end where steam is admitted to the cooler middle where the exhaust ports are located, comparably with the temperature of the steam during admission and expansion. Indeed, the temperature gradient in the metal might be represented roughly by the admission and expansion lines on the indicator diagram.

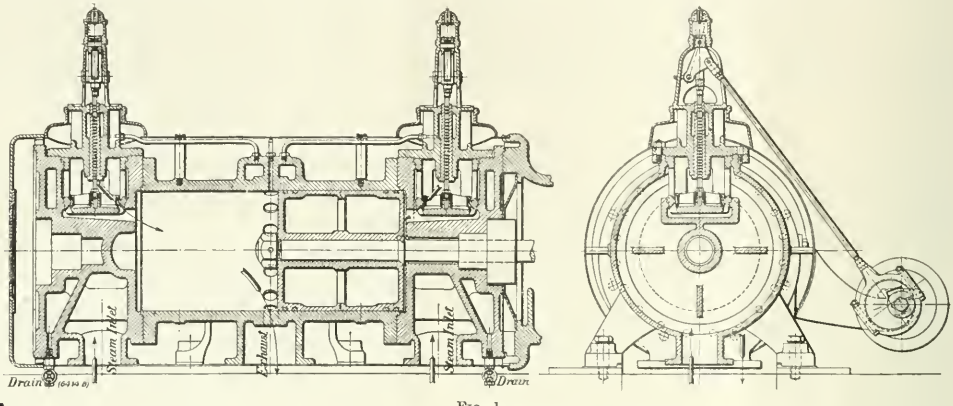
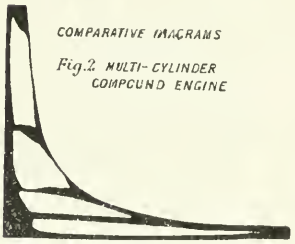
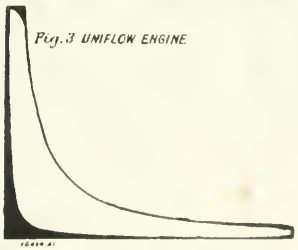
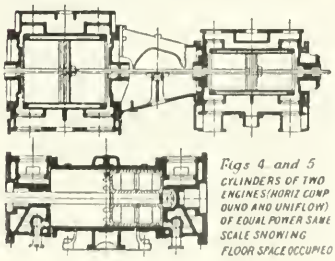


FIG. 1.







Figs 4 and 5 CYLINDERS OF TWO ENGINES (HORIZ COMP OUND AND UNIFLOW) OF EQUAL POWER SAME SCALE SHOWING FLOOR SPACE OCCUPIED

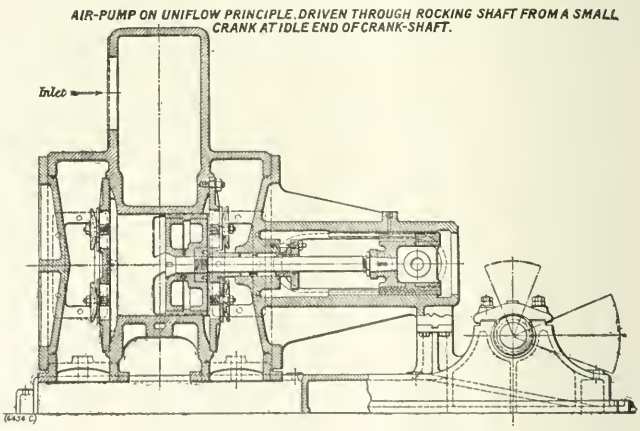


FIG. 6.

Readings taken from a cylinder close to the inside surfaces of the cover and barrel have given the following temperatures: Cover, 400 degrees F.; barrel half-way between cover and exhaust ports, 250 degrees F.; at middle near exhaust ports, 160 degrees F. So marked is this temperature gradient that, to prevent trouble in working, it is necessary to bore "uniflow" cylinders barrel shaped when cold, that is, larger in diameter at the middle than at the ends. The barrel temperatures vary very little when working either with saturated or superheated steam, due to the early cut-off, thus making this type of engine particularly suitable for superheated steam.

The high diagram factor obtained by the suppression of the losses which occur between the cylinders and in the receivers of multi-cylinder compound engines contributes to economy, Figs. 2 and 3, also the compressed steam at approximately admission pressure, and the cylinder-ends which are kept hot by live steam flowing through the cylinder covers.

2. Flexibility—The steam consumption per brake horsepower hour at full load is low, owing to the small number of glands and working parts absorbing power in overcoming friction, nor does it increase appreciably with reduction or increase of load. At three-quarter load, it is practically the same as at full load; at half-load and at 25 per cent overload it increases by about five per cent of the full load consumption.

3. Speed Control—It is claimed that the uniflow engine is specially adapted to give steady turning under either uniform or fluctuating loads, first because the indicator diagrams when corrected by the forces required to accelerate and retard the heavy reciprocating parts show a fairly uniform effective pressure on the crank-pin, and, secondly, because the whole of the power is developed in one cylinder, so that any change in the position of the governor produces its full effect in a single stroke.

4. Upkeep.—Compared with a multi-cylinder compound engine, which is its nearest equivalent for economy, the cost of upkeep, oil and stores will be greatly reduced owing to the extreme simplicity of this engine and the small number of working parts.

5. Floor Space and Foundations.—As will be seen from Figs. 4 and 5 (annexed), which represent the cylinders of two engines of equal power drawn to the same scale, the floor space occupied by the uniflow engine is less than that required by the tandem (or any other multi-cylinder) horizontal compound engine. The foundations will also be smaller and less costly than for a compound engine.

Details of Design.

Having dealt thus briefly with the history, special features, and advantages of uniflow engines in general, the author would add a short description of two of these engines. The first was built by Messrs. Robey & Co., Limited. It is of 1,100 ihp, and drives a generator at a speed of 120 rpm., with an overload of 25 per cent for two hours, and of 50 per cent for a few minutes. The steam pressure is 200 lb. per square inch, and the superheat 200 degrees F.

The cylinder, 35 in. diameter by 40 in. stroke, consists, as shown in Fig. 1, on page 163, of a barrell, a plain casting, carrying only the exhaust belt and two small brackets for bolting to the baseplates, and of two end-covers containing the steam valves. These last are double beat of large diameter, and small lift, the upper part being movable relatively to the lower, so that the distance between the two valve faces can always adjust itself to the distance between the faces of the seats when the latter varies under changes of temperature. The course of the steam through the covers, steam valves, cylinder, and exhaust valves is indicated clearly by the arrow on the figure.

In the bottom of the cover is a small passage leading to a relief and drain valve, and in the latest engines to a small valve, which opens automatically when working non-condensing to by-pass steam to the exhaust and keep the compression at a pre-determined limit. The piston is made in two parts as light as possible. It carries four packing rings, two at each end, and, owing to its great length, requires no tail rod. The admission valves are raised by cams and rollers operated from eccentrics on a valve shaft. This shaft also carries a powerful combined centrifugal and inertia governor which, by suitable mechanism, turns the eccentrics through small angles and thus regulates the point of cut-off. The bed is of massive construction, carrying double bearings of the four-part type with circular back wedges, so that it is impossible to nip one end of the bearing on the shaft. It is attached to the cylinder-cover by eight large studs carried by bosses on the cover in order to make the surface of metallic contact as small as possible, and thus reduce transmission of heat from the cylinder to the bed. Forced lubrication is provided throughout by a rotary pump which can be operated by hand before starting the engine. A small hand-wheel is provided at the end of the valve shaft. This permits the engine speed to be varied five per cent up or down while running.

The condenser is usually placed immediately under the cylinder, and the air pump, Fig. 6, also on the uniflow principle, is driven through a rocking-shaft from a small crank at the idle end of the crankshaft. On the engine illustrated an oil-extractor is placed between the cylinder and condenser to prevent oil reaching the cooling tower. The condensate enters the pump through slots in the center of the barrel when these are uncovered by the piston at the end of its stroke, and is forced out through delivery valves on the ends of the barrel. These are the only valves employed, and can be easily and quickly changed when required.

The engine just described, like most uniflow engines, runs at a fairly fast and constant speed of revolution, but there are cases in which slow and very variable speeds are needed. In such cases the engines are often of large size, and the designs for the cylinders, heavy pistons, valve-gears and governors require very careful consideration and modification.

An engine recently built by Messrs. Galloway, Ltd., of Manchester, for driving sheet mills at a steel works in South Wales, is a case in point. This engine is believed to be the largest uniflow engine in the world. It is coupled directly to the mills and runs at 28 rpm. The steam pressure is 150 lb. to 180 lb. per square inch, and the superheat 150 degrees Fahr.

The cylinder in this case is 60 in. diameter with 6 ft. stroke. It consists of a middle piece containing the exhaust ports and passage, two short tubes forming the cylinder-barrel and two ends containing the steam admission valves. The two barrel-pieces are connected to each other by bolts passing through the exhaust belt and relieving the latter from longitudinal stress. An inspection door is provided to give access to the cylinder without removing the cylinder-end or piston.

A safety valve, actuated by a cam-gear, is fitted to each end of the cylinder to control the compression pressure by opening automatically whenever the vacuum falls. When starting the engine, the valve is open and operates till it closes automatically when the vacuum is formed. The piston is fitted with four rings like that already described, and is provided with a number of slippers flexibly supported and capable of independent radial movement to meet changes in the cylinder diameter due to change of temperature,

The internal faces of the covers and the piston faces are polished to reduce condensation losses. The admission valves are of cast iron, double beat, so constructed as to remain tight under all temperatures. Each valve is driven by an eccentric carried on a valve shaft, the cut-off being determined by the position of a sliding block in a vibrating link.

A centrifugal governor, acting through a floating lever device, and controlling the small balanced piston-valve of an oil-pressure servo-motor cylinder, determines the position of the block.

The piston-rod cross-head is of mild steel with shoes lined with white metal and phosphor-bronze steps, the housing for these being cut out of the solid. The connecting rod is forked at the cross-head end, but solid at the big end with phosphor-bronze steps adjustable by a wedge. The crank is overhung. The flywheel, carried between the crankshaft bearings, is 32 ft. diameter and weighs 160 tons. The main bearings and the crankpin are lubricated with stiff grease instead of oil, at the request of the owners of the engine.

In conclusion, the author ventures to express the hope that his paper may have helped to convince the members of the simplicity, economy, and advantages of the uniflow engine.

Specifications For A Rolling Mill

Is It to Be for Profit or Production? Cases Where Short Sighted Reasoning Is Used in Selecting the Type Mill to Be Installed, and Consideration Is Not Given to all Factors Involved.

By W. H. MELANEY.

IN THESE days of progress in mill design and construction, it is very much a question whether we do not sometimes let our desire to be right up to the minute, bias our judgment as to that which is best suited to properly fill the requirements of the proposition we have in mind.

If we had a small cellar to excavate, we would not think of purchasing a steam shovel to do the work, although it could be done in a much shorter time than would be possible with pick and shovel and a team. But the small amount of work to be done would not justify the outlay required to purchase this modern tool.

Yet this would be no more foolish than some of the things that are done in many instances, where orders for new equipment in a rolling mill are being placed. A firm for instance decides that it will be to their advantage to put in a new roll train for rolling bars, either to increase their production or perhaps to make for themselves some particular stock which they have heretofore purchased in the market. They assume that as they are going to spend their money on new equipment they want something modern and up-to-date, and not a mill such as some of their competitors are operating.

So they immediately get in touch with the builders of rolling mill machinery and ask them to quote on a modern mill for rolling such sizes and shapes as they require.

The builder, with this limited knowledge of their requirements, proceeds to show them designs of the most modern equipment he has built for this purpose and gives them data as to the amount of output, weight of train, power to drive, approximate cost, etc., and it usually happens that the cost is several times what the would-be purchaser had in mind when he asked for this information. However as he had already decided that he would build a modern mill while he was about it, he swallows his disappointment and decides that as he can roll a ton of material so much cheaper on the modern mill than on the old fashioned type that perhaps the outlay will be justified after all.

Without analyzing all of the conditions that go to make up the cost of the finished product he places the order for the new equipment, and perhaps later on is horrified to find his finished stock costing him more a ton than he could purchase it for in the open market.

Short-Sighted Reasoning.

This is because he failed to take into consideration all the elements that go to make up his cost per ton. A modern mill of course will produce several times the tonnage in the same time as its older predecessor but it also costs several times as much money to build and this first cost always remains as a fixed overhead operating against the cost of production of the mill and goes on and on whether the mill is operating or standing idle.

This mill due to its design for producing greater tonnage, is more or less a special mill and requires more time to change from one size to another, as usually several stands of rolls must be changed in order to produce the desired bar. The result is that for every minute the mill is down your tonnage is being reduced proportionately, while the overhead is still plugging along at its usual gate. This means that to keep your production costs down to the proper figure, it is necessary to have on order a large tonnage of some particular size of bar before it would pay to start the mill on that order. A continuous run is necessary to get large output and consequent lower cost of production yet this happens only just as long as this condition can be complied with.

Adverse Conditions.

But whenever adverse conditions happen, such as lack of orders or not having sufficient tonnage of any one size to give the mill a fairly continuous run without stopping to change rolls, your tonnage cost quickly begins to mount until you have a fair sized deficit instead of a profit to show for your run and you begin to lose your faith in the efficacy of a modern mill. This is no fault of modern mill design but is the inevitable result of lack of forethought in selecting the proper mill to suit your conditions.

Modern Mills.

A modern mill under proper conditions, and this means big tonnage, long lengths, and standard sizes, is a great money maker and justifies the large expenditure of money necessary for its construction but was never

intended by its designer to be used to produce small orders or unlimited sizes nor where frequent changes of rolls in a days work is required.

Where such conditions as noted above prevail the old type mill such as an ordinary bar or guide mill costing only a fraction of the amount a continuous or semi-continuous mill would cost and capable of turning out only a fraction of the output of these modern mills, would be the more profitable mill to install, because it would still have sufficient capacity to take care of the output required. The overhead charge, while costing more per ton of output capacity would still be much less than this same small tonnage would cost if made on the more costly modern equipment.

Furthermore, when the old type mill is down for any reason such as lack of orders or changing of rolls the overhead cost of such shutdown would be much less in comparison.

It would seem ridiculous to install a mill with an output of 250,000 pounds a turn on small sizes if the total of your orders or requirements is only 100,000 pounds per turn as the higher first cost and consequently higher fixed overhead would be prohibitive.

Costly Labor-Saving Machinery.

Another feature usually overlooked is that labor saving machinery is not always desirable or profitable from an investment point of view. If the first cost of the equipment necessary to be installed in order to cut down the number of employes required to do a certain amount of work plus the cost of upkeep, would increase your fixed overhead charge more per ton on your required production than the cost of hand labor per ton on this same production, then it is obvious that hand labor should be used.

The only excuse that could be offered for the installation of the costly labor saving appliances under such conditions would be inability to get sufficient hand labor to do the work. Yet many installations have been made under the guise of progress that have never returned in profits the amount of the interest on the investment much less the cost of the upkeep. This of course is generally due to the fact that the limited tonnage required never had justified the expenditure of the money necessary to cover the first cost of the installation.

Hand Labor.

The human machine, no matter how cold blooded this statement may sound, requires no upkeep so far as the employer is concerned. When men fail to be efficient they are replaced by younger, more efficient men, without extra cost to the manufacturer. There is no overhead to take care of except their daily wage. You are still getting all the output you require or can make use of and when the roll train is idle for a few days the daily wage ceases to be an overhead charge.

Therefore if the required output of any installation is so small that hand labor will easily produce it within the specified time, then it is ridiculous to install costly machinery with its rapid and expensive depreciation to do this work simply because it can be done quicker, when you have no way to utilize the time saved. You only need so much tonnage and therefore the time saved is wasted but your overhead charges such as interest on investment, and upkeep still go on.

Old Type Mill.

For instance a bar mill that would roll all the tonnage required in a given time when hand operated by means of the old-fashioned hooks instead of the expensive driven and tilting roller tables and served by the old hand charged heating furnace instead of the costly modern continuous furnace, will produce a limited tonnage at a much less cost per ton than this same small tonnage could be produced on the more modern equipment.

This is the reason why in times when keen competition exists due to scarcity of orders and lack of demand for any particular product, that many of the old so-called obsolete mills are able to make a little money for their owners when the bang up modern mill is eating its head off in idleness. It therefore behooves the purchaser to know the condition under which he must operate before he can select the type of mill that will best fill his requirements.

Manufacturing Steel and Iron Tubes

Youngstown Sheet and Tube Company's Method of Manufacturing Pipe Processes Used in Forming and Welding Steel Tubes—Process of Threading, Testing and Finishing.

By H. C. EBRIGHT.

PIPE in various forms and sizes being so important among the products of the Youngstown Sheet & Tube Co., and the processes used in its manufacture being so varied and complicated, three separate articles in this series will be devoted to this subject. The first will contain a brief description of the forming and welding of lap-weld and butt-weld tubes.

Tubes, or pipe, as they are commonly known in this country, were made as far back as 1790, when lead was used for this purpose. This material lacked strength and physical properties necessary for structural, conductive and mechanical purposes, however, and efforts were soon made to produce pipe from stronger materials, such as brass and iron. It will be seen that the entire history of iron and steel tubes does not date back much farther than 100 years. The earliest tubes were made for gun barrels by taking a strip of wrought iron and bending it so that the edges over-lapped, and then welding these edges by hammering with or without swages. It was not until the year 1815 that the first tubes were made for gas purposes, and these were no longer than six feet.

Looking back into the early history of the tube industry, we find that the most simple and obvious methods of manufacture were used. What we now call "lap-weld" tubes were made by taking a flat strip of steel of suitable thickness and width and bending this into a tube shape until its edges were either

soldered or welded together. In 1812 the first patents were granted covering machinery and apparatus for carrying out this process.

Butt-weld tubes were first made by James Russell in 1824. He bent the iron skelp into cylindrical form until the edges butted together, and then welded these edges with a power hammer fitted with dies. The first attempt to carry out the modern process of making butt-weld pipe was made by Cornelius Whitehouse in 1825, when he used a chain bench placed in front of a furnace and arranged to pull the heated pipe through a die or bell by chain and tongs actuated by power. This, with modifications and improvements, is the same process used today.

Wrought iron made by the puddling process, was at one time the only available material for the manu-

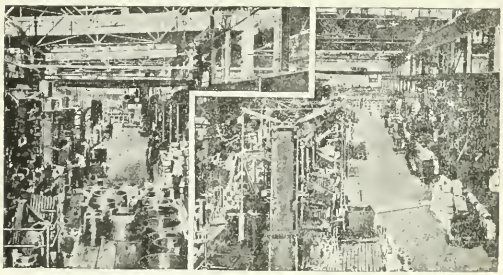


Fig. 1—Welding pipe by the lap weld process.

facture of pipe, but during the last thirty years this has been largely superseded by a purer grade of iron not only on the care used in its manufacture, but upon the quality of the steel.

All pipe made by this company is either lap-weld or butt-weld, and is manufactured by bending skelp and welding the edges together, either overlapping or edge to edge.

Our mills produce pipe in all standard sizes from one-eighth inch to twenty inches in diameter. By skelp is meant a flat sheet or plate used in making pipe by either of the above prosesses. Still another process for making tubes is by forming or drawing them from solid billets. The product is known as seamless tubing. The Youngstown Sheet & Tube Co. has six lap-weld furnaces, of which three can be heated either with coke or producer gas, while in the other three coke gas only is used. It has also five butt-weld furnaces in which either coke or producer gas can be used. These furnaces are all of the regenerative type.

The size of pipe is usually determined by its inside diameter up to and including the 12-inch size, and all larger is rated according to its outside diameter. Lap-weld pipe is made on our mills from two inches to 20 inches inclusive, from skelp 7¾ inches to 64½ inches in width.

One of the most important features in the manufacture of pipe is the use of skelp uniform in width and gauge, together with steel of proper analysis. On account of the larger production of our furnaces and the many different products made in our works, we have the opportunity to select the grade of steel essential for making the best quality of pipe, an advantage which is not enjoyed by all manufacturers of tubes in this country

The Lap-Weld Process.

In making lap-weld pipe the skelp is first rolled to the necessary length, width and gauge for the sizes to be made, and the subsequent process consists of two operations, bending or drawing, and welding. The skelp is first heated to a cherry red in the bending furnace and then put through a pair of scarfing rolls which bevel the edges so that when overlapped and welded the seam will be beat and smooth, with practically the same thickness as the remainder of the pipe wall. After this is done the skelp is drawn through a bending die where it is given roughly the cylindrical shape of a pipe with the edges overlapping, but not welded. This formed skelp is then rolled into a motor-driven buggy and hauled to another furnace, where it is recharged and heated evenly to a welding temperature of about 2,600 degrees F. Next it is pushed into rolls located at an opening in front of the furnace which draw it through and completes the welding operation. These rolls are two in number, and have semi-circular surfaces which together form a complete circle. Between these rolls a cast ball or mandrill of approximately the same diameter as the internal diameter of the pipe to be made and shaped somewhat like a projectile, is held by a strong bar while the pipe passes over it and between the rolls. This subjects the lapped edges to a pressure between the rolls and the mandrill and welds them firmly together, at the same time reducing the thickness of the lap to that of the remaining wall of the pipe. The welded tube is then carefully inspected for any flaw that may have occurred in the process.

If it passes inspection, the tube while still hot is then put through a similar set of rolls called "chilled rolls," and a mandrill held in the same position as in the welding rolls. This removes any inside irregularities and secures accuracy in the internal diameter. It is next put through another set of similar rolls called "size rolls" without the mandrill, and these give an equal pressure on the whole circumference, thereby securing accuracy in the outside diameter.

The pipe next enters a set of rolls called "cross rolls" which consists of two rolls set with their axes

Fig. 2- Skelp passing through die in process of forming and welding butt-welded pipe.

askew. The surface of these rolls is so curved that the pipe is in contact with each roll practically its full length, and this gives a clean surface and makes the pipe straight. The length of these cross rolls varies from four to sixteen feet, and after passing through them the pipe is approximately straight and uniform at all points.

After this process the lengths of pipe are then slowly rolled up an inclined cooling arch and allowed to cool off slowly and uniformly, the constant turning keeping it straight during this process. At the end of this rack the pipe is put through a cold straighten-

ing press, after which it is again inspected and then passed to the threading department.

The Butt-Weld Process.

Butt-weld pipe is made in sizes of one-eighth inch to three inches inclusive, the skelp ranging in width from 1-2/10 inches to 11¾ inches. It is essential that skelp for butt-weld pipe be rolled true to length, width and gauge for the size of pipe to be made. The edges are square, or, in some cases, slightly beveled so that the side of the skelp to form the interior wall of the pipe is not quite as wide as the side which is to form the exterior. The butt-end process is somewhat simpler than the lap-weld, since the latter has two operations, while the former has only one, both forming and welding of the skelp being done at the same time. Skelp for butt-weld pipe is not square at the end, but has the corners clipped off so that when it starts through the bell it will curve in the form of a cylinder. The skelp is charged into the furnaces by mag-

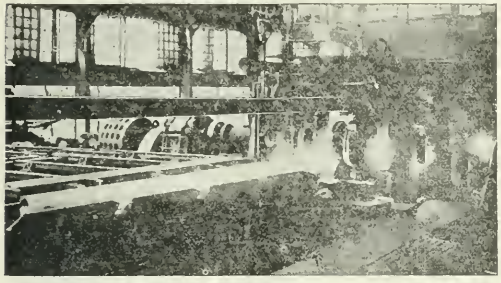


Fig. 3—Where couplings are made for "Youngstown" pipe.

netic rolls, and after it is heated to a welding temperature the ends are seized by tongs in the hands of the welder, who then drops over the handles of these tongs a bell-shaped die. He then drops over the handles of the tongs on an endless chain which grasps them and pull tongs, skelp and bell out of the furnace together. The bell is caught and held just outside of the furnace and the skelp forced through, forming it into a pipe, and welding the edges firmly together.

The pipe is carried along the endless chain to a pair of rolls called "size rolls," the tongs being automatically released in the meantime. These size rolls give the pipe the external size desired. From these rolls the pipe passes to a cooling bed on which the pieces, about 20 feet in length, are slowly rolled until cool. After inspection the pipe is sent to the galvanizing or threading department for further finishing.

In making extra heavy butt-weld pipe, on account of the thickness of the skelp it is necessary to draw the pipe through several dies, each of which is slightly smaller than the last, and this pipe must be reheated between each draw until the same is thoroughly welded.

The next process is inspection, and in this the pipe is inspected for any defects which may have occurred in the welding process. If any such defects are found it is rejected. Pipe that has passed inspection is then sent to the threading machines to be either cut with plain ends or fitted with "V" threads.

The term "plain end" may describe either pipe with ends cut square, which is used for patented sleeve joints, such as the "Dayton" or "Dresser" couplings, or pipe in which the end of the walls is beveled to various degrees for welding by the oxygen-acteylene or electric welding process for forming the joints. A more general definition would be pipe which has been finished but not threaded.

Threaded pipe is furnished with various threads distinguished from one another by the number of "V" threads per inch, the taper per inch and other differences, depending on the class of material and the purposes for which it is to be used.

For gas, steam and water pipe the standard for screw threads is the "Briggs" standard, adopted as the United States standard October 27, 1886. All such pipe has taper threads. The inclination of these, established by the Briggs standard, is 1 in 32 to the axis, or, as it is commonly stated, ¾ of an inch taper per foot on the diameter.

The total length of thread is made up of three parts. The first part consists of "perfect" threads, the second of "partially perfect" threads and the third of "imperfect" threads. The perfect threads are those that have perfect tops and bottoms and are tapered the entire length, in other words, threads of full size and shape. The partially perfect threads have perfect bottoms but are not perfect on their tops. The imperfect threads are not perfect either at top or bottom. The variation of these threads is, of course, due to the taper, those at the end of the pipe being of full depth and "perfect," while those farthest from the end are of partial depth, and, therefore, not complete at either top or bottom. The imperfect threads are not essential to the forming of a good joint, and are only incidental to the present method of cutting threads by means of a die. Ordinarily, there are three imperfect threads; in some cases four occur. The number of imperfect threads depends on the angle at which the "lead" of the die has been ground.

In addition to those above described, various other threads and tapers are employed in the manufacture of pipe, for which standards have not yet been adopted in the United States. All manufacturers, however, use the standards above described, so far as these types of threads and taper are concerned. The exterior surfaces of the threads have an angle of 60 degrees, but the threads are slightly rounded at both top and bottom, and it follows that the height or depth of the thread is not exactly equal to the pitch, but only four-fifths thereof.

Threading is one of the most important features in the manufacture of pipe, since upon it depends not only the strength and tightness of the joints, but also the ease and rapidity with which the pipe may be installed. To secure such a joint it is very essential that the pipe be made to the proper size and that the threads be clean and smoothly cut. For this work the selection of dies and their proper care is very important. Good threads can only be produced with good dies. The die consists of a frame or holder and a set of "chasers" that have the proper "lip," "chip space," "clearance" and "lead." The chasers are the cutting tools which actually form the thread.

"Lip" is the inclination of the cutting edge of the chaser to the surface of the pipe. The proper lip causes the chips to curl off clean and leave a smooth thread.

"Chip space" is the space required in the holder in front of the chaser to provide room for the accumulation of chips during the cutting of the thread.

"Clearance" is the room between the threads of the chasers and the threads of the pipe.

"Lead" is the angle which is machined or ground on the front of each chaser to enable the die to start on the pipe.

To produce the best results the die must have a suitable number of chasers. This number depends upon its size.

The dies are, of course, mounted in properly arranged machines driven by power.

In addition to the equipment described above it is necessary to use a good lubricating oil during the threading operation. This oil is kept flowing over the die and pipe. Without proper oil a good die will not cut a good thread.

After the pipe has been threaded it is again carefully inspected for the purpose of detecting any bad threads. If none of these are found, the couplings are next put on by hand, being turned on the proper distance in this way, and then screwed up to the allowance by machines called "socket screwing machines." Both pipe and couplings are then again inspected for any defects possibly overlooked in the previous inspections, and if they pass this final examination they are sent to the testing department. Here both are given the final test by being subjected for a short interval to an internal hydrostatic pressure. This pressure is secured by placing the pipe between two water tight heads, one of which is adjustable to suit the various lengths, and is connected with a hydraulic pipe line. The test pressures applied to each length vary from 400 to 2,500 pounds, according to the size and kind of pipe. Any bad welds or holes in the pipe will show up immediately under the pressure used.

If the pipe stands this hydrostatic test, it is next bundled and tagged, or, in the case of 2-inch and larger, is stenciled with marks showing the kind, length and weight. It is now ready for shipment as black pipe.

General Notes on Finished Pipe.

All weights are figured on the basis of each cubic inch of steel weighing .2833 pounds, and iron weighing 2 per cent less. All pipe, except that heavier than standard weight, is generally classified in regard to size by its normal inside diameter in all sizes from ⅛-inch to 12-inch inclusive. Sizes larger than these are generally classified by the outside diameter. From this fact come the symbols O.D. and I.D., meaning outside diameter, and inside diameter. In pipe, casing, tubing, etc., heavier than standard weight, the extra thickness of the walls reduces the inside diameter, which is relatively somewhat smaller in standard sizes of this pipe than it is in the same sizes of standard weight pipe.

All pipe is cut to random length except on special orders. On such orders the variations in length must not exceed one-eighth of an inch over or under, unless otherwise arranged. The permissible allowance in weight is 5 per cent above and 5 per cent below for standard weight pipe. For extra strong, or extra heavy pipe the allowance is greater.

The kinds and sizes of pipe at present regularly manufactured at Youngstown Sheet and Tube, are as follows:

Steam pipe ⅛" to 16" (O.D.)
Line pipe ½" to 20" (O.D.)
Drive pipe 2" to 20" (O.D.)
Tube 2" to 4".
Casing 2¾" to 15½".
California casing 4¾" to 15½".
Youngstown casing 2¾" to 15½".
Drill pipe 2½" to 6".
California tubing 2" to 3".
Extra strong pipe ⅛" to 15".
Double extra strong pipe ½" to 8".

In addition to these, however, they make a great many kinds of special pipe, such as signal pipe, dry kiln pipe, plugged and reamed pipe, and others. They also manufacture English tubes for steam, gas and water lines. The English tube is slightly different in the thickness of its walls, and therefore there is inside diameters of this pipe and those of the same sizes in American pipe.

There is also a difference in the shape of the "V" threads, and a different number of threads per inch are cut on the respective sizes. The English type of thread is known as the "Whitworth." The angle of this thread is 55 degrees and its depth is 64/100 of the pitch. Up to the present they have manufactured English steam, gas and water tubes in standard sizes from ⅛ inch to 6 inch inclusive. Tubes for Argentina and South America are furnished with English threads, but are somewhat lighter in weight than the standard English tubes.

Design of Ports for Open Hearth Furnaces

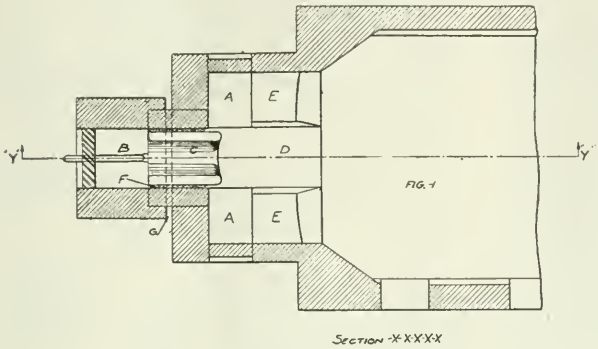
Two Types of Circular Water Cooled Ports of Simple Construction Having Many Advantages Over Old Designs Now Successfully Used by Lackawanna Steel Company for Over Two Years.

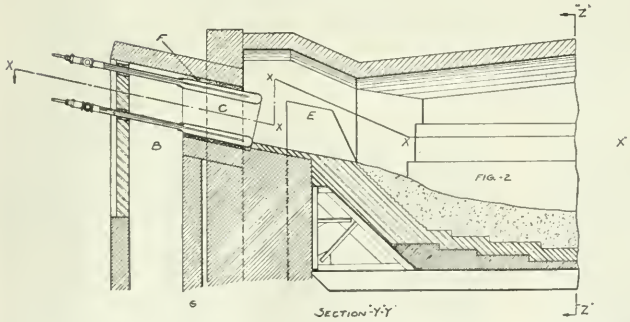
By HERBERT F. MILLER, JR.
Lackawanna Steel Company.

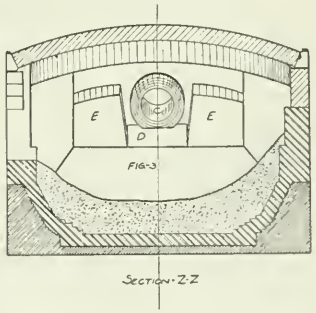
OPEN hearth furnace men have looked for the development of a port for open hearth furnaces that use producer gas for fuel which would surpass the older types of dry and water ports in ease of upkeep and in speed of production. They have wished for a port that would throw the flame so as to make it easy on the brickwork and at the same time would act constantly toward keeping a low bottom in the hearth. They wished for a furnace that would have a flame which worked on the charge from the time it entered the hearth until it went out as a waste gas, and to have a flame that would come into the hearth pot and go out relatively cool so that it is easy on the brickwork of the end-walls also.

All furnace men have long desired a port that would do away with the exhausting and often fruitless labor of keeping both dry and water ports in the shape of their original lines. Therefore, two types of ports having these qualities have been developed and patented by George T. Downs and Herbert F. Miller, Jr., of the Lackawanna Steel Company.

One of the two types of ports is designed to be suspended independently of the brickwork by means of water cooled pipes. The other type is built in the brickwork and thus gets its support. Other than these differing means of support, the ports are identical. The original ports with over two years successful service behind them look good for many more years. The port is a hollow, water cooled flue, tubular in shape. It is less than 40 per cent of the weight and surface of other water cooled ports.







NOMENCLATURE

A-A	AIR UPTAKES
B	GAS UPTAKE
C	PORT COOLER
D	COMBUSTION CHAMBER
E-E	BLOCKS
F-F	GROUND SILICA BRICK PACKING
G-G	AIR SPACE BETWEEN GAS & AIR UPTAKES

In the construction the port extends from the gas uptake into the air port, but not entirely across the air uptakes. This permits the rising current of preheated air to forcibly impinge the stream of gas as it issues from the port. By this action the combustion starts immediately and rapidly, so that by the time the gas reaches the bath, the flame is in shape to melt the scrap. In the older types of water cooled and dry ports the effect of the lower part of the stream of gas as it enters the hearth is a cooling one instead of a melting one and this over an area of many square feet. In other words, the location of the gas port insures the gas being surrounded by air as it leaves the air port so that the bottom of the flame will be as hot next to the bath where the heat is needed as the top of the flame in the older types of ports.

The changing of the usual freezing zone under the gas flame into a melting zone accounts for the ability of the furnace to constantly keep a low bottom in spite of large limestone charges, lumpy slags, or other adverse conditions.

Then, too, the character of the flame is changed by this type of port. Usually the flame hits the stock under pressure and splits on it going against the side walls and roof and causing rapid wear. Here, however, the flame comes against the stock just as rapidly but comes more as a pull from the stack. This causes the flame to hug the scrap closely and keeps it from hitting the side walls in any great degree.

The design of port used acts to keep the tail end of the flame low on the outgoing end and to keep the flame away from the side walls by keeping the draft in fairly straight central lines in the hearth.

The flame comes into the hearth clear of the roof and at the second door coming in the flame is not much higher than the wicket hole and it goes out of the hearth at the same level.

The gas port itself being of small dimensions and the exposed surface, a minimum makes its cooling effect on the incoming gas and outgoing waste gases negligible. This is proven by the fact that the incoming flame is hotter on this type of port than that from a dry port. One installation in a furnace charging 160,000 pounds of metal with a 14 per cent limestone burden has ports only 29 inches long and is making its heats in less than 10 hours, many of them going out under eight and nine hours. Installations in larger furnaces are giving a larger tonnage per hour. A comparison of the working conditions between this type of port and any other water cooled or dry port is interesting.

Dry ports are the most difficult of all ports to

keep in shape. From the start the dry ports are constantly changing in shape. The slopes may either be built up or get big holes in them. Bricks melt and drop out of the port arches, plugging up the port, causing the flame to be deflected and burning the roof. The ports made of brick widen through wear and have to be lined up frequently. These ports develop leaks in the arches and walls. These leaks grow in number and size as the port gets older, making a hot working furnace. Labor involved in trying to overcome these defects is most exhausting and often ineffectual. Lastly, the silica running off of the ports makes the banks porous and thin, thus permitting breakouts.

Water ports in general overcome the above troubles in a degree. The import defect in water ports is that a deposit forms inside of the port and rapidly builds up. To remove the deposit long bars must be used and this in a white heat which causes the bars to bend quickly. The labor involved is most trying. Often it takes hours of hardest sledging to even partially remove the deposit in the port. This work has to be done at least every two days or the ports will plug up. It is difficult to get men to do exhausting labor constantly.

Now, in the circular water cooled ports, there is not much of a deposit formed due to the shortness of the port. What deposit formed there may be pushed out or blown out in less than two minutes. The dirt which may flux together cannot flux to the water cooled metallic surface on which it is deposited and for this reason it is easily removable. The lines of this port are what the drawing calls for each and every day. The men who work the furnaces having these ports say that they are the easiest ports to keep in shape that they have ever worked on.

The circular water cooled ports are so small in comparison with other types of ports that the amount of water needed for cooling is a minimum. The small size of the ports also helps to keep the ports clean. This is because the sediment in the water does not have much time to settle out and because of the small amount of water used, not much sediment is carried into the port. However, the ports are equipped with cleanout and agitator pipes through which the dirt, if there is any, may be washed out while the furnace is in operation.

It will be noticed that the circular ports are simpler in design than the older types of ports and this one fact serves to assure the operator of more satisfactory service than he has hitherto received.

Design of Experimental Rolling Mill

Description of Details of the Design of the Experimental Mill of Bureau of Rolling Mill Research—Outline of Questions That Are Perplexing to Rolling Mill Engineers.

By W. B. SKINKLE,
Director, Bureau of Rolling Mill Research.

PART V.

IN concluding this description of the experimental rolling mill it might be well to outline briefly some of the many questions that are perplexing rolling mill engineers at the present time and show how methods have been provided in the experimental mill to study and perhaps solve these problems.

As an example, take the problem of the power required to drive a rolling mill. Almost any number of examples could be given to show where the most careful figures of engineers have contained errors of from 50 to 300 per cent in these calculations. The large electric companies have a fund or experimental data taken from actual tests on commercial mills from which they figure the power requirements. These formula however do not take into consideration each of the many variables but insert a "constant" which holds over a small range of product.

These variables might be classified as follows:

1. The temperature of the steel.
2. The area of steel in contact with the rolls.
3. The velocity of deformation.
4. The diameter of the rolls.
5. The diameter of the necks.

So far as the writer knows the only formula which takes into consideration all these variables is one advanced by Prof. W. Trinks, head of the Department of Mechanical Engineering at the Carnegie Institute. He attacks the problem in the following manner:

When steel passes through a set of rolls, there is an arc of contact between steel and rolls which exerts a large separating force P, at some lever arm, against which the rolls must be turned.

The magnitude of this force depends, first, upon the temperature of the steel, second upon the area of the steel in contact with the rolls and third upon the rate of rolling or "compression velocity."

The arc of contact and area of steel in contact with the rolls may be determined grahically as shown in Fig. 36 in which a square bar is put into an oval. Sections 1, 2, 3, 4 and 5 show the changes that take place in the bar as it moves through the pass. They are taken from equal incruments of drafts as is illustrated in the side elevation. The projected contact area is developed from these sections and is shown in the sectioned figure above the side elevation.

The probable lever arm of this force P is taken as .7 a as shown in Fig. 37 where "a" is the horizontal projection of the arc of contact.

Fig. 38 shows a series of "temperature-velocity" curves which were plotted from a number of tests. The ordinate gives the number of pounds of force "P" for each square inch of projected contact area between steel and rolls. The abscissa gives a series of "compression rates" and is determined from the quantity $\frac{\text{Loge } \frac{H}{h}}{T}$

where "H" is the height before entering rolls "h" is the height after leaving rolls and "T" is the time in seconds

required for the roll to turn through the angle of contact or o< on Fig. 37.

With this information it is easy to figure the network required to turn one roll and then double this value for the net work required to roll the steel.

For example suppose that o< = 18°, "a" = 1⅝," the projected contact area = 2.30 square inches. Temperature of the steel = 2,000° F. the mill operated at 200 rpm, "H" = 1 1/16" and "h" = 11/16", the roll neck

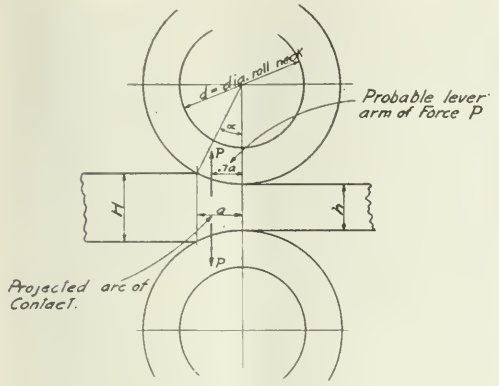


Fig. 37.

diam 7 inches. Then "T", the time to roll through the arc o< or 18° = $\frac{18 \times 60}{360 \times 200} = 0.15$ seconds. H ÷ h =1 1/16 ÷ 11/16 = 1.55 and $\log_e$ of 1.55 is 0.4383 then $\log_e \frac{H}{h} = \frac{.4383}{.015}$ or 29.2 which may be called 30 for even numbers. $\frac{}{T}$

From the curve for entering temperature of 2,000° F. in Fig. 38 we find that the pressure between rolls and steel for the value 30 is considerably over the maximum values given. These curves however have been carried far enough to give the maximum pressure between rolls and steel, as above the maximum given, the point of liquifaction of the steel is approached and this factor tends to reduce the pressure very greatly.

It is therefore safe to assume the maximum of 20,000 lbs. per square inch of projected contact area as the proper pressure between steel and rolls, and having 2.3 square inches in this area the total force "P" will be 20,000 × 2.3 = 46,000 lbs. This force is applied with a lever arm of .7 × 1⅝ = 1.14".

The torque necessary to turn one roll (exclusive of roll neck friction) is therefore 46,000 × 1.14 = 52,500 inch lbs.

The roll neck radius was assumed as 3½" and the total load on both necks would be 46,000 lbs.

Inasmuch as the neck grease is squeezed out of the bearing during most of the pass, this requires the assumption that only a slightly lubricated surface of cast iron on bronze exists during rolling.

The coefficient of friction in such a case would be about .20. Then the torque required to overcome friction would be 46,000 × .2 × 3½ = 32,000 inch lbs. or the total torque to be applied to each roll would be 46,000 × 32,000 = 78,000 inch lbs., and there being two rolls to the mill, there must be delivered 78,000 × 2 = 156,000 inch pounds of torque which at 200 rpm is equivalent to 500 hp delivered to the stand of rolls while bar is passing through.

The foregoing calculations would offer a method of arriving at the power requirements if the various assumptions could be checked against more experimental data.

For example lever arm of the force "P" is assumed to be .7 a. This value could be checked very easily if means were at hand whereby the net work required to roll the steel could be separated from the total work.

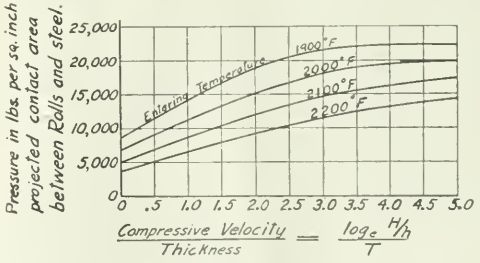
Again the coefficient of friction of .20 between slightly lubricated bronze and cast iron was assumed. The hydraulic support cylinders shown in Fig. 27 and the hardened steel rings of Fig. 29 offer a means of separating the work losses and checking these values. The values as used were taken from a large number of tests made by many different men and from a number of tests made by Prof. Trinks personally but he is far from satisfied that they are final and will not at some later date be found to be in error.

A very recent test on a large and modern electric driven cold mill installation which came to the author's notice, showed a difference of only 25 horsepower in 1,200 between no load and full load operating conditions. This means that only 2 per cent of the total power applied to the mill was converted into useful work and that the other 98 per cent was lost in friction on the roll necks and in the transmission machinery.

The possibility of saving and improving in the design of the roll housings themselves has already been pointed out and need not be repeated.

Another large field for the experimental mill is the development of passes for continuous mills.

One of the most difficult problems in the design of these mills is the determination of the "controlling diameter," or that diameter which when multiplied by 2π times the area of the section, will give give the volume of the steel delivered per revolution of the rolls.



H = Height before entering rolls.
h = height after leaving rolls.
T = Time in seconds, req'd to turn thru angle α.

Fig. 38.

If a bar is in several sets of rolls, placed in tandem, at the same time, the exact volume of steel taken into the first set per unit of time must be delivered from the last set in the same length of time. If the last set tries to deliver more than the first set receives the bar will stretch and the passes underfill. If the last set delivers less than the first set received the bar will buckle, or overfill the passes. Either condition causes a great deal of trouble.

The forces acting between rolls and steel, the slippage and the forward excrusion of metal from the rolls, form so complicated an action that an analytical method of determining the controlling diameter of the rolls is impossible.

The experimental mill offers opportunities for a great deal of work along these lines. At present the product of continuous mills is limited almost entirely to sheet bar, merchant bar, small billets and thin flats.

It would be a simple matter to bolt a mechanical device onto the delivery guide box, that would mark or nick the section being rolled, once for each revolution of the roll. After a bar 10 or 20 "revolutions long" had been rolled its actual length and section area could be measured. The accurate figuring of the "controlling diameter" of the roll would then be a very simple matter. Rolls for a continuous mill could first be tried out with the housings assembled as a hand fed bar mill as shown in Fig. 9. This would determine the natural flow of the metal in that particular pass, uninfluenced by the effects of other passes in the train. The rolls could then be given their final turning and their "controlling diameters" brought into proper relation to each other, as determined by the gears of the drive.

In this manner the product rolled in a continuous mill could be greatly extended. The large number of troubles encountered when new sections are first tried out, together with the very high cost resulting from the tying up of a producing department have been factors which have hindered the development of this type of mill, in spite of the resulting low labor cost and very large tonnage, which results from their successful operation.

A number of different lines of investigations and of problems in each of these lines that could be studied is very great. These are greatly extended by the very complete mechanical, chemical, physical testing and metallurgical laboratories which are attached to the Carnegie Institute and would be thrown open for the use of the bureau.

The educational possibilities which the bureau offers are also quite interesting.

During the war the Carnegie Institute like many other colleges in the country had several thousand men stationed at the schools for short extensive courses to fit them for special mechanical duties with our army and navy. These courses were quite successful and many men were trained in the short space of six weeks to be quite proficient along some one of the various technical lines required in the service.

The thought occurred to officials of the institute that if education of this character could be so successfully used in war it could be used with equal success in peace.

Almost every one is familiar with the great amount of what might be termed "folk lore" that fills our mechanical processes and how hard it is to overcome many of these perversions or superstitions.

How many have talked for example with heaters who insist on all kinds of notions regarding furnaces and the burning of fuel. Many of them firmly believe that the more air they admit the more heat and greater economy they secure and that this economy is secured by "burning the air." The thought of excess air is not considered nor is the possibility of a perfect mixture of gas with the theoretical quantity of air.

If a group of these men could be brought together for one week and given a lecture in the morning, a demonstration in the afternoon and a general discussion of the day's work in the evening, they would return to their jobs in far better shape to perform their duties intelligently than they were before they received the instruction. The theories of combustion and chemical union of the elements entering into the reactions could be illustrated with circles, crosses, and stars in colored chalk and made so plain that they would be easily grasped.

Much of the "folk lore" would be dispelled in this manner.

Take as a second example a young helper on the rolls who desires to become a roller. Before he can realize his ambition he must know just what causes each one of the many troubles that are constantly occurring around a rolling mill. He must also know just what to do to remedy this trouble. The place where he gets the largest part of his information is in the cobble pile. The cobbles while giving him an excellent lead on what is happening in the roll pass are not true records as the metal continues to flow very slowly from the static pressure of the rolls even after the rolls have been stopped. With the reversing motor which drives the experimental mill a short bar could be rolled part way through a pass and then returned to the roller.

This partly rolled specimen would be a true record of what was happening in that pass as the rolls would not be stopped long enough when reversing, to allow any flow due to the static pressure of the rolls, to take place.

The hot saws on each side of the mill also permit the cutting of short sections of bar after each complete pass. These short sections could later be sliced into one-quarter inch lengths and each man furnished with a sample of what actually happened in that particular pass.

A series of lectures and demonstrations on a mill where tonnage is not a factor would give the young roller more experience in six months of three nights a week than he could get in almost as many years of work on a producing mill.

Demonstrations of faulty rolling as well as successful passes could be also made and the causes and remedies studied.

STEEL CORPORATION AIDS ALL EMPLOYES TO BUY U. S. BONDS.

The Bethlehem Steel Corporation and its employes have found a common ground for mutual benefit. They have gotten together on the sound financial basis of Liberty bonds. At the request of the men themselves, the Bethlehem Company and its subsidiary companies have just perfected a plan by which the employes can invest regularly a part of their wages in government securities and obtain those securities at current market prices, thus obtaining the opportunity for profit which those prices present.

Under the plan, the company will purchase at market prices various issues of Liberty bonds and Victory notes and hold them for employes who desire them. The bonds are sold to the employe at the same price at which they were bought and will be paid for by weekly, fortnightly, or monthly reductions from the pay of the employes who purchase them. Advance in the price of the bonds after they have been subscribed for will not affect the employes who will obtain them at the price current when the subscription was made.

When the bonds has been completely paid for it will be delivered to the employe with accrued interest.

Modern Development of Fuel Gasification

Development of Modern Gas Producers in Germany—Operation of the Producer and the Processes by Which the Complete Utilization of all Constituents Are Obtained.

By HUBERT HERMANNS.

ACCORDING to the chemical-physical processes, two methods of obtaining the useful gases, contained in our fuels, can be applied, viz: distillation and gasification. With the first method, which is used in the manufacture of illuminating gas, the fuel is heated in air-tight vessels, called retorts; this gives a combustible gas, a distillate, composed of a mixture of oily and watery substances and coke. When applying the second method, the fuel is converted entirely into a combustible gas, leaving no residue except ashes. This producer gas burns evenly and without developing smoke or soot, attaining a comparatively high temperature of combustion, which may still be raised considerably by preheating the gas and the air required for combustion. Producer gas has a fairly uniform temperature. The quantity of air necessary for combustion can be kept within small limits, thus allowing an easy regulation of the process of combustion. The gas may be burned either with an air-excess or an air-deficiency, giving either an oxidizing or a reducing flame.

Producer gas is generally used where high temperatures are required, for instance, for heating or melting purposes or in internal combustion engines. For heating purposes, the application of producer gas is increasing daily and there can be no doubt that the so-called "semi-gas" furnaces will soon all be replaced by producer gas fired furnaces for the reasons that producer gas is more economical, that it can be burned without smoke, that the combustion of producer gas can be easily regulated and that it is possible to gasify low grade fuels in the producer.

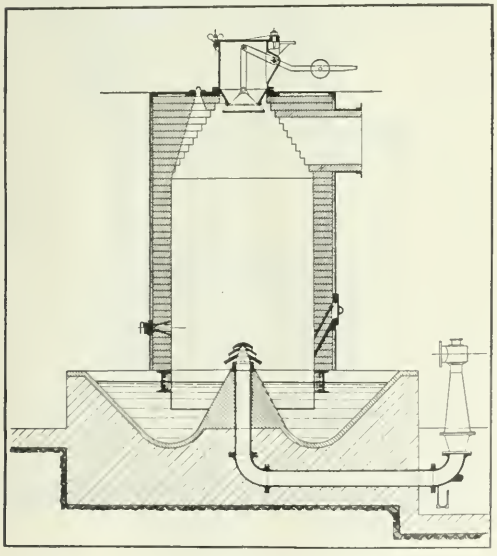


Fig. 1.

The modern gas producer allows the gasification of all known fuels, anthracite, bituminous coal, semi-bituminous coal, lignite, peat, wood, coke, charcoal, shales, coal or coke breeze, etc. The product obtained will be the more valuable, the lower the quantity of volatile constituents in the coal. This quantity varies considerably with the different fuels: Wood contains about 82 per cent, peat 60 to 65 per cent, bituminous coal 45 per cent, best anthracite 5 per cent. The higher, therefore, the contents of free carbons in the fuel, the better will the fuel be for gasification. This rule, however, has nothing to do with the economy and efficiency of the gasification, which depend upon other factors; these factors, being outside the scope of this paper, will not be dealt with here.

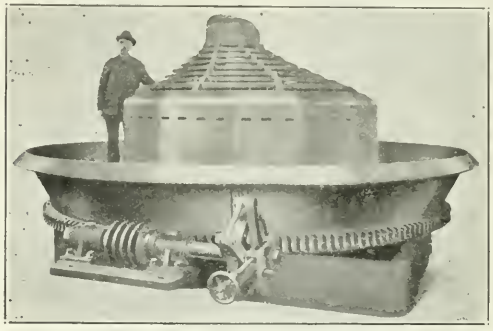


Fig. 2.

The quality of the gas generated in a producer is entirely independent of the heat value of the original fuel. Under certain conditions a fuel with a low heat value may be superior, technically and economically, to a fuel having a high heat value.

Fuels which are not fit for gasification in the original state, for instance coal or coke breeze, or brown coal, having a high content of moisture, can be remodeled into briquetts, thus making them better fit, not only for gasification, but also for unloading, transportation and general handling.

The principle underlying the gasification is the transformation of the free carbon in the fuel into carbon monoxide. The first product generated when burning carbon is carbon dioxide, which, coming into contact with more carbon, is reduced to carbon monoxide. To completely reduce carbon dioxide to carbon monoxide, a temperature of at least 1,800 degrees F. in the combustion zone is required. If this tempera-

ture becomes lower, part of the carbon dioxide will stay unreduced and at about 850 degrees F. the formation of carbon monoxide will cease. It has been found by recent investigations, that there is a fixed relation between the temperature and the carbon monoxide—carbon dioxide ratio, and that every temperature corresponds to a certain definite ratio of two constituents.

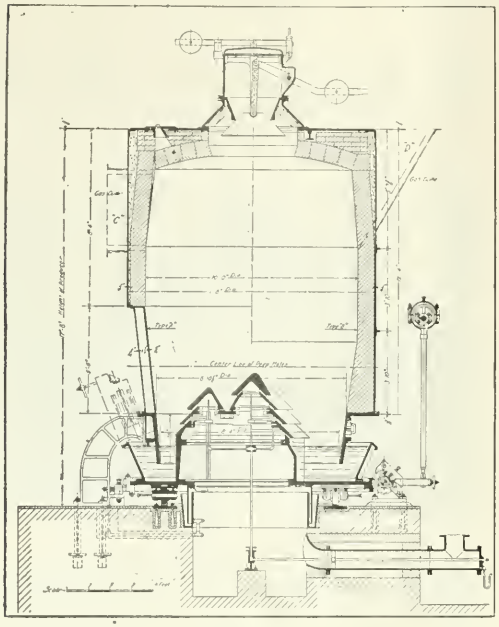


Fig. 3.

If the air blown into the producer is mixed with steam, this steam will, in the combustion zone, be decomposed by the incandescent carbon. If the temperature is above 1,800 degrees F. hydrogen and carbon monoxide will be generated, if below 1,800 degrees F., the products will be hydrogen and carbon dioxide. If steam only is blown with the producer, the result will be the formation of water gas, consisting of hydrogen, carbon monoxide and some carbon dioxide.

The hydrogen, obtained from the decomposition of the steam, increases the heating value of the producer gas. Care must, however, be taken not to blow too much steam, as its decomposition and superheating will require a considerable amount of heat, which is taken from the incandescent fuel, thus lowering the temperature in the combustion zone. The quantity of steam blown should be enough to prevent the formation of clinkers, which not only increase the manual labor, but also attack the lining of the producer.

The hydrogen in the gas reduces its total specific weight, thus increasing the tendency of the gas to flow upward in the furnace and to attack the roof. Besides a large percentage of hydrogen in the gas tends to decrease the length of the flame, which is not favorable for furnaces of great length, for instance heating furnaces or open hearth furnaces. On the other hand, an increasing amount of hydrogen increases the flame temperature.

When gasifying fuels containing large amounts of moisture, like brown coal, it is not necessary to mix steam with the air blown into the producer for gasification. In fact, such an addition might be detrimental, as it might drown the producer. In the distillation zone, the moisture of the fuel is driven off with the gas as water vapor, acting at an unwelcome ballast and reducing the temperature of combustion of the gas. Gas made from brown coal-briquetts contain, without the addition of steam to the air, about 10 to 12 per cent hydrogen. Besides, this kind of fuel is not able to decompose the same quantity of steam as bituminous coal on account of the smaller amount of coke contained in it. However, ideas and experience differ widely in this matter among fuel experts. One example may be mentioned to prove this statement. Of two producer gas plants, using the same kind of brown coal for gasification, the one had to be worked under all circumstances and conditions, without the addition of steam to the air, whereas the other plant could not get along at all without using steam. There is a wide field open for scientific investigations, aside from the fact, that such conditions may be due to a large extent to local operating conditions.

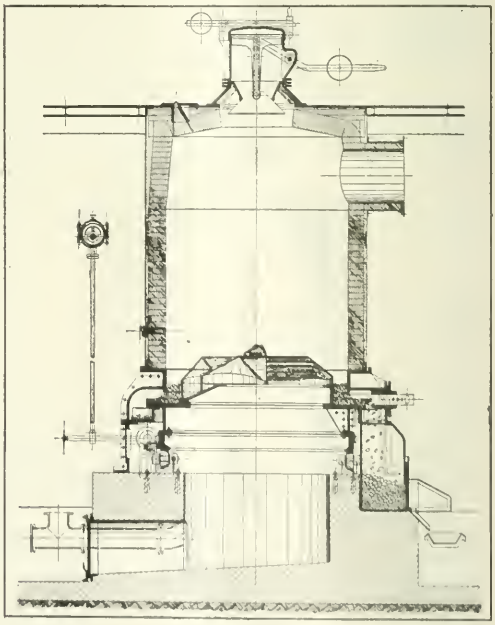


Fig. 4.

The quantity of steam to be mixed with the air, must, as a rule, be regulated according to the kind of fuel to be gasified. Fuels containing a large amount of volatile matter, require less steam, because during the process of gasification water vapor is formed; to this water vapor has to be added the moisture in the fuel. The more water vapor the gas contains, the higher will be the heat losses. The largest quantity

of steam to be added to the air can, nautrally, be allowed for the gasification of coke and charcoal, which are nearly pure carbon. If pure carbon is gasified, one pound of water vapor may be added to 75 cubic feet air without having to be afraid of heat losses. As one pound of carbon requires 75 cubic feet air for gasification, the upper limit of the addition of steam

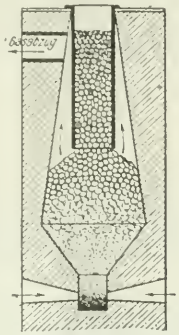


Fig. 5.

will be one pound of steam for one pound of carbon.

Preheating the gas and air will allow to increase the quantity of steam blown. Thus, for coke, practical experience has shown, that 130 to 175 grains of steam per cubic foot of air are required when a gas is wanted containing a large amount of hydrogen. For ordinary conditions, 1/3 of a pound of steam is sufficient for one pound of fuel. Under any and all circumstances, care must be taken, that the temperature in the gasification zone does not fall below 1,800 degrees F., as a large part of the heat is required for the decomposition of the steam, one pound of which consumes about 2,785 Btu. In case the temperature falls below 1,800 degrees F., the steam will, as was shown above, not form carbon monoxide and hydrogen, but carbon dioxide and hydrogen. At the same time, the height of the combustion zone will be reduced, which again is followed by an increase in the CO_2 contents in the gas, thus generating a wet, lean gas, high in CO_2 and of low heating value.

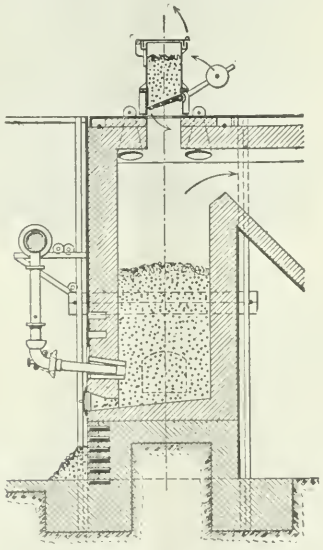


Fig. 6.

The thickness of the fuel bed in the producer depends upon the kind of fuel to be gasified. Fuels of small size require a thinner bed than coarse fuels. Fine coals of ⅜x¾ inch size require about 2 feet thickness, coke of 1¼x¾ inch size require 30 inches, coke of 1¼x2 inch size about 4 feet and coke of 2x2¾ inch size about 6 feet thickness. For run-of-mine coal a thickness of 6 to 8 feet may be necessary. For bituminous coal, too thick a fuel bed is not favorable for a good working of the producer, as it will increase the formation of soot and tar.

Very important for a satisfactory working of the producer is the uniform size of the fuel, because large

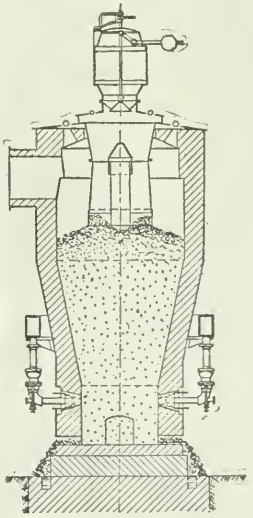


Fig. 7.

lumps or fine dust mixed together, will prevent an even gasification; they will, furthermore, cause the formation of channels in the fuel, and will also increase the amount of combustibles in the ash. The channels will allow free air to mix with the gas on top of the fuel bed, thus diluting the gas.

The selection of the fuel, however, will, in most cases, be determined by the local conditions.

The operation of the producer and its efficiency are influenced considerably by the more or less complete gasification of the coal. It must, therefore, be the desire of the operator to reduce the ignition losses in the ashes to a minimum. In the old types of producers, the ashes sometimes contained 50 per cent of combustibles, whereas in the new types the coal is gasified to such an extent, that only about 4 to 5 per cent unburned coal remains in the ashes.

The trend in the design of modern gas producers is directed, in the first place, towards the complete

utilization of the high-grade fuels in the producer, by extracting from them the tarry constituents in the form of low temperature tar, and, in the second place, toward the gasification of low grade fuels, like coke-grit, slack or fuels with a high ash content, which mostly could, up to the present time, not be used for

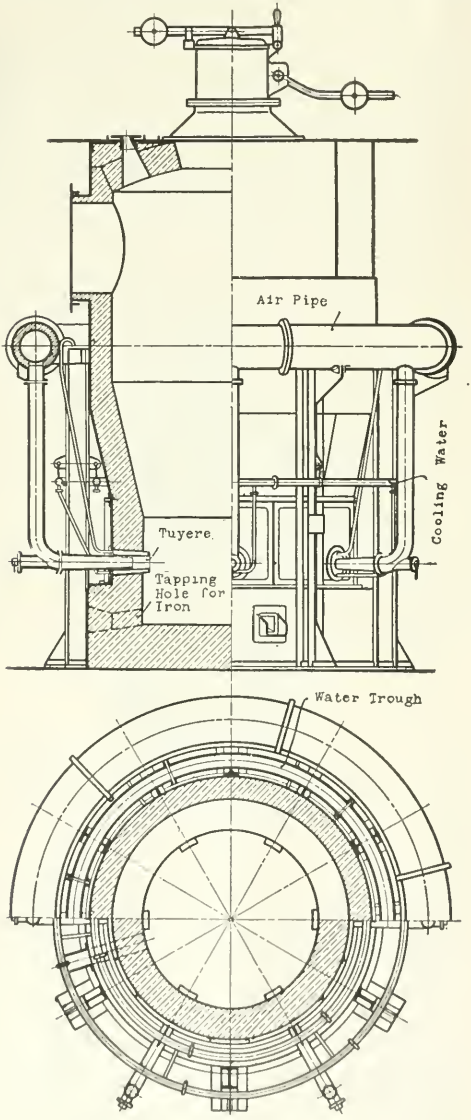


Fig. 8.

the purposes in question. The producer, best suited for gasification of these fuels are either of the rotary grate type or of the slagging type. The oldest types of these producers had either plane or inclined grates. The air required for combustion was sucked in by the natural draft of the furnace, of which the producer formed an integral part. They were built entirely of brick, with a firebrick lining, but without an iron shell. Holding an intermediate place between a semi-gas furnace and a producer, they are not used any more to any large extent (with the exception of the glass industry). The fuel gasified in these "producers" is mostly screened raw brown coal, sometimes brown coal briqutts, or a mixture of the two. The efficiency of these producers seldom exceed 30 per cent, the other 70 per cent are lost through one or more of the following reasons:

1. With the ashes, which contain at least from 10 to 15 per cent combustibles, whereas modern gas producers give ashes with not more than 4 or 5 per cent.

2. Due to an incomplete reduction of carbon dioxide to carbon monoxide, caused chiefly by too thin a fuel bed. The gas produced has, therefore, a high percentage of carbon dioxide, which makes it unfit for heating a furnace to the required temperature.

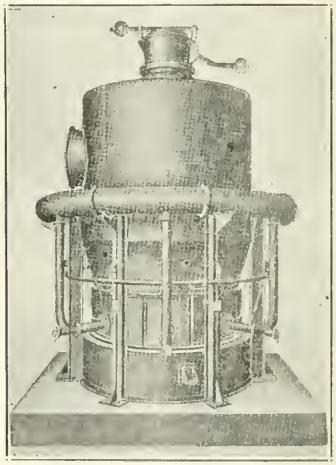


Fig. 9.

3. Through radiation from the walls, hopper and grates.

4. By gas losses through leaks around the hopper and doors.

5. Through the deposition of the heavy hydrocarbons in the ducts in the form of tar.

These losses are, to a large extent, due to the design and operation of these types of producers. It is impossible to run a producer efficiently which has an inclined grate, open to the atmosphere and without the least possibility of regulating the amount of steam and air required for gasification. It is the duty of the supervising engineer, to prevent such a senseless waste of fuel, caused by the inefficient design and operation of these producers. This can only be done by careful instructions to the operator, unless other and more efficient types of producers are installed.

In some cases it has been thought to be of advantage to preheat the air before it enters the producer. This was done by means of the waste gases

from the furnaces. Such a preheating is, however, useless, at least when the gas is to be used in regenerative furnaces. The action of the regenerating chambers is due to the temperature difference between the incoming gas and air and the outgoing waste gases. If the temperature of the gas and air, entering the chamber, is high, the result will be a high stack temperature, i. e.: the chambers will work with a low efficiency. Although, therefore, it is desirable to make use of the heat in the waste gases, it can easily be

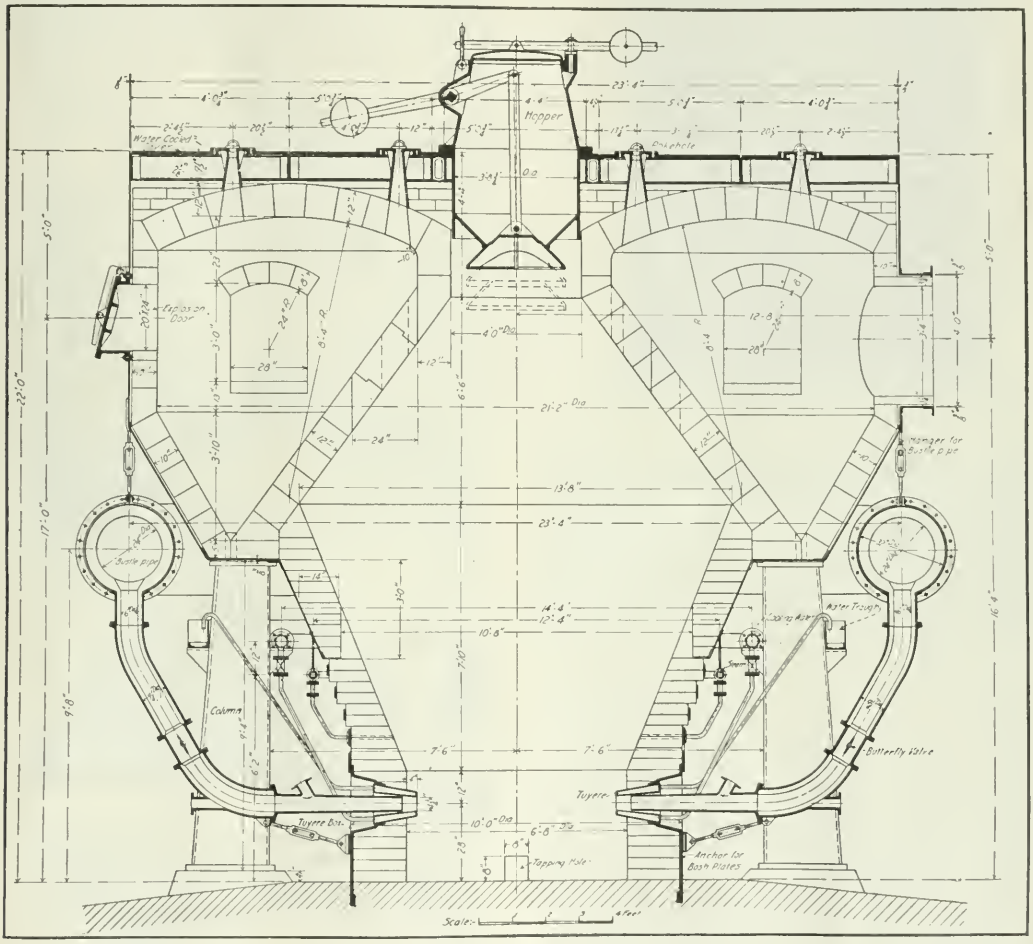


Fig. 10.

seen, that the way this is done in the case mentioned above, is not the right one.

The grate generally and in modern gas producers is the round grate, sometimes developed in the form of a round sloping grate, sometimes in the form of a central blast hood (Fig. 1). Through a combination of the two types the combined round central blast hood has been obtained. The original purpose of the grate, i. e.: the support of the fuel column, has been abandoned; at present the grate is mostly designed in such a way that it allows a uniform distribution of the stream and air over the whole area; it is designed as the name implies, as a blast hood. The fuel column rests on the flat bottom of a trough, called waterseal, which allows the removal of the ashes without interfering with the running of the producer.

The automatic removal of the ashes has been tried several years ago by means of a revolving water seal or a revolving grate, and it was mainly due to Kerpely that this type of producer found a wide distribution. Kerpely built a rotary grate (see Fig. 2) for the gasification of Bohemian brown coal and made, in 1906, the first tests in Germany, but with little success. At the same time and at the same works, where the tests were made with the Kerpely producer, a Rehman producer was tried out. These tests showed the superiority of the Rehmann grate over the Kerpely grate, as the former can easily be changed to suit

the pecularities of the fuel to be gasified. For a baking coal, for instance, the grate was sub-divided into several smaller ones, each one having an apex of its own (see Fig. 3). These smaller grates were with each other, forming one large grate. They prevented the fuel above the grate from coming to rest and forced the ashes to move by a continuous and uniform

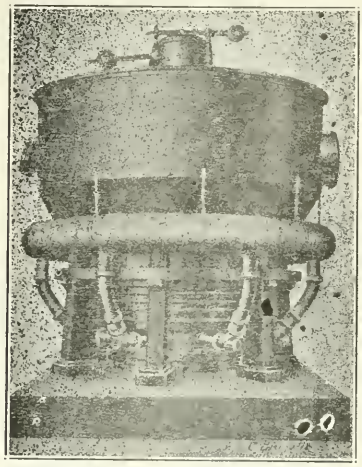


Fig. 11.

motion from the center toward the outside. For fuel, which did not bake or which do not form large lumps of ashes, the grate was built much lower (see Fig. 4). A third kind of fuel, especially several types of rhenish brown coal, furnish ashes, which bind like cement, when coming in contact with water. For these coals, the grates had to be closed against the outside air by means of an iron shell. The ashes had, then, to be removed through doors in this shell, without allowing them to come in contact with water.

The original gas producers did not have any grates or blast hoods at all. The designers of these oldest types used for their model, the blast furnace, which, like the cupola, has no grate. Being designed after these furnaces, the producers were also operated like them. At the lower part of the shaft the air entered by means of tuyeres and the slag was tapped while in the liquid state. To obtain this liquid slag it was necessary to run the producers hot and to add fluxes. As such a flux iron furnace slag was used, which was charged with the fuel.

The first producer of this type (see Fig. 5) was put in operation by Ebelmen around the year 1840. The air entered above the bottom through tuyeres, below which there was the tapping holes for the liquid slag. The gas was discharged at the upper part of the producer. The producer was not closed air-tight on the top and, in order to prevent the escape of the valuable gas, a piece of large pipe was provided, which reached down into the producer and which was always filled with fuel. There is no doubt, however, that this arrangement could not prevent some losses of gas. On the other hand, the hot gases, flowing, on their way out, around the pipe which was filled with coal, caused the dissociation of this coal, thus driving out of it and wasting the valuable hydro-carbons, which are decomposed at low temperatures. There may also in the lower end of the pipe, have taken place a formation of carbon dioxide, which, rising through the fuel, might have been reduced to carbon monoxide. It can, therefore, easily be seen, that the losses connected with the Ebelmen producer must have been large.

Around the end of the seventies of the last century, producers without grates were developed at Witkowitz (Fig. 6), which were built after the same principle and which were in operation until 1890. Here lime was charged in addition to the iron furnace slag for fluxing the ashes. The high temperature in the producers, however, caused a quick destruction of the brick work. Of a similar design was a French producer of the slagging type (Fig. 7) which afterwards was introduced into German practice. In this type of a producer blast furnace slag and limestone were used as fluxes.

Later designs tried to develop a grateless producer, which would allow to increase considerably the quantity of coal charged per hour, thus increasing the amount of gas generated, and which would furnish a gas suitable for industrial and metallurgical furnaces of any kind. For the construction of these producers the experiments and the experience obtained from the French slagging type were considered. The fuel used is coke to which iron furnace slag is added as flux. At first it was found, that, when running the furnaces with gas made from coke, the influence of the heat on the charge was less favorable, than when gas made from raw coal was used, although the analyses showed

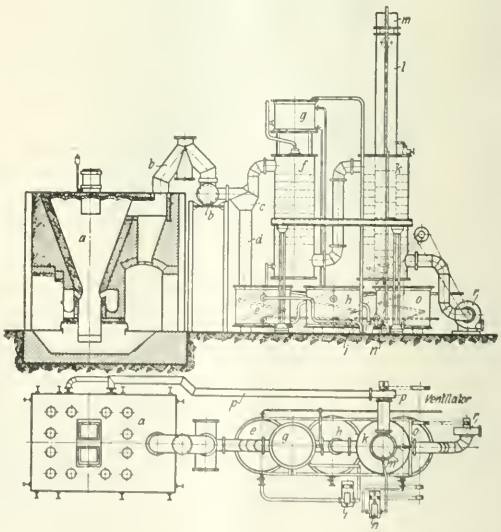


Fig. 12.

the gases to be of about the same composition. Further investigation, however, proved that the difficulties could be eliminated by regulating the gas-air mixture.

Successful experiments with the slagging type of producer were recently made at the plant of the Georgs-Marienhuette at Osnabrueck. These producers are blown with a large amount of air, no steam being added. The

gas is, therefore, remarkably dry. The high heat value is due to a high percentage of carbon monoxide, which approaches the amount theoretically possible (50 per cent) whereas the percentage of carbon dioxide is very low.

Producers of the slagging type are especially of advantage for fuels with a high ash content (Figs. 8 and 9). In these producers it is possible to gasify fuels with as high as 50 per cent ash. All that is necessary is to vary the kind and quantity of the fluxes to suit the composition of the ash. Experience has taught, that for the purpose low grade iron ores can be used to advantage, which otherwise would be unfit for reduction. The iron thus charged, is obtained as pig iron and can be sold as a

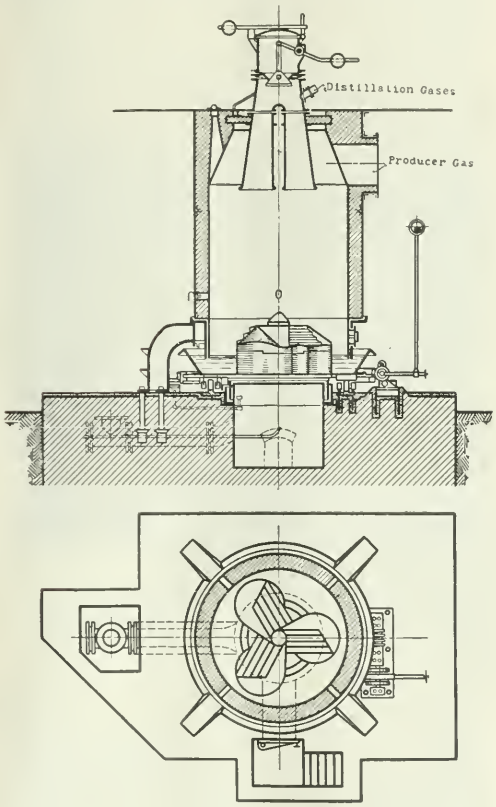


Fig. 13.

by-product, thus reducing the cost of operating the producers.

At a Westphalian steel plant the producers were originally operated without the addition of iron. However, it was soon discovered that it worked satisfactorily only for a few hours after operation was started. By and by the slag became more visceous and finally it froze completely, thus causing the producer to be shut down. At first it was thought that the slag was cooled by coming in contact with the cold bottom of the producer and a separate combustion chamber was built under the producer. But this only deferred the trouble without eliminating it. It was then tried to remedy it by charging pig iron or iron ore with the fuel and this proved to be a complete success. After this no trouble was experienced any more in keeping the slag liquid. The heat contained in the molten iron is entirely sufficient for this purpose. If there would not be a continuous exchange of heat between the molten iron and the slag, there would not be any chance to keep the slag liquid in a cupola.

Next it was tried to make the slagging type of producer suitable for the gasification of small sized and fine fuels. As the air must, for this purpose, be blown with a comparatively high pressure, the danger arises that small particles of the fuel will be blown out with the outgoing gas. This has been found to be true during experiments made at the Georgs-Marienhutte. The regenerating chambers were clogged with flue dust in a very short time. It was, therefore, necessary to enlarge the area of the fuel bed, in order to reduce the velocity with which the gas left the producer. But even then the carrying away of fine particles of the fuel could not be prevented entirely.

To overcome the difficulty a new and remarkable design has been developed recently. It consists of the addition of a large circular chamber above the producer (see Figs. 10 and 11), which is divided by walls into several chambers. The gas flows through these chambers, and there deposits its particles of dust, as the velocity comes down to nearly zero. The dust particles glide down through pipes containing gates into the tuyeres and are blown with the air into the producer.

During the last few years the trend of the development in the gasification of fuels has been directed through separating and collecting those hydrocarbons which boil at a low temperature and form what is called "low temperature tar." This tar is entirely different from the tar obtained in coke ovens or artificial gas plants. It has been discovered, however, that this low temperature tar can be changed into coke oven tar by superheating and dissociating it. But low temperature tar contains valuable constituents as benzene, lubricating oil and paraffine, which can be obtained easily from the tar. Low temperature tar proper is obtained, as the name implies, at comparatively low temperatures by means of dry distillation. Care must be taken, that the distillation gases are not superheated, in order to prevent decomposition. It is, therefore, necessary to take these gases off at once, thus preventing this coming in contact with the hot walls of the producer and flues.

Special means for the protection of the distillation gases against superheating are not required, where the distillation temperatures lie between 480 degrees and 1,020 degrees F. with a gas temperature of between 570 degrees and 1,380 degrees F. It is, in these cases, sufficient to simply extract by proper means, the low temperature tar from the main gas current. This can best be done in practice when the gas temperature in the producer is below 750 degrees to 840 degrees F.

An installation of this kind for reclaiming the low temperature tar is shown in Fig. 12. Right above the gas producer *a*, is the main gas line *b* in which a small part of the tarry vapors and the steam is condensed. The rest of these vapors are removed in the separator *c*, from where they flow into the vessel *e* through a downcomer *d*. The gas then passes through the scrubber *f*, which contains perforated plates, whereas the tar, which is to be wasted, comes from the vessel *g* and flows through a distributor against the plates in *f*. Due to the close contact between the gas and the finely distributed tar, the tarry particles in the gas will be washed out and at the

same time, part of the water vapors in the raw gas will be condensed. Tar and water then flow from the scrubber to the vessel *e*, from where the pump *i* lifts the tar into the vessel *g*. There, the tar is, by means of a heating coil, heated to such a temperature, that the temperature in the scrubber is not less than 120 degrees F. The light volatile parts are washed out in the wash-tower *k* and cooling tower *l*. Above the cooling tower a vessel *m* is provided, into which is pumped the washing liquor, collected in vessel *o* as foul-water, by means of the pump *n*.

If the temperature of the gas in the producer is between 930 degrees and 1,380 degrees F., conditions are different. In such a case it is necessary to separate the gases containing the low temperature tar from the rest. It has been found to be of advantage for this purpose to use charging boxes, which are filled with the green fuel and which bring it down to the top of the fuel bed in the producer. Fig. 13 illustrates a gas producer with rotary grate and the charging box. The fuel is charged through a hopper, built in the usual way and is exposed in the charging box below to a temperature of about 930 degrees F. The hot gases, playing around the box cause the separation of those parts of the fuel which are distilling at a low temperature and which are collected separately.

It is apparent that the development in fuel gasification has reached a turning point, which might cause a fundamental change. On the one side there is the question of gas generation with the reclamation of the valuable low temperature tar, which will make Germany independent from other countries as far as lubricating oils, grease and benzene is concerned; on the other side we have the restless gasification of coal in a producer of the slagging type. The main advantage of this mode of operation is due to the possibility of gasifying large quantities of fuel on a small area, connected with a decrease in cost of operation and labor. The utilization of the fuel is more efficient and more economical, where tar is separated. But the further development of the process depends mainly upon the market conditions for the by-products.

It seems, however, to be of advantage, to combine the two methods of working. This can be done in the following way: The large grateless producers of the slagging type, with a high capacity, are filled up for the separation of low temperature tar, charging raw coal. The design can be modeled after the Ebelman producer, changing the inserted piece of pipe into a charging box. The gasification zone is then entered by coke, which can be gasified at a high temperature, while the liquid slag is tapped at the bottom.

Of course, it can only be found by practical experiments and tests, if this proposition is feasible. It may, for instance, be difficult, to combine the provisions required for separating the low temperature tars with a gas producer of the slagging type, having a large diameter and capacity, as the time during which the coal remains in the charging box, may be too short to insure a complete distillation. There is, furthermore, the possibility, that small particles of the fuel (half-coke) will be carried over into the lines on account of the high air pressure. Actual tests with the different apparatus may show a way out of the difficulties and may lead to the discovery of a satisfactory arrangement. There is no doubt that the combination of the distillation retort or charging box with a producer of the slagging type would change the technical and economical foundation of the gas generation, it would, above all, allow the gasification not only of the coal and coke breeze but also of large quantities of green coal in a slagging type producer under the simultaneous separation of low temperature tar.

Increased Efficiency in the Open Hearth

The Effect Roller Bearings Applied to Rolling Stock Has Upon Reducing Transportation Costs—Comparative Tests Made With Cars of the Plain Bearing Type.

By PHILIP C. GUNION,
Engineer, Hyatt Roller Bearing Company.

ALL operating men desire to produce maximum tonnage at a minimum cost. New methods for producing steel by cutting out unnecessary delays have not only been tried but have also been adopted as standard.

The transportation problem about the open hearth is of vital importance, whether it is transportation of scrap, limestone, hot metal or ingots. The melting process may be developed to a high degree of efficiency but a delay in transporting materials will run up operating costs. Within the past five years considerable time has been spent by many steel men in an effort to bring the transportation of materials, with minimum operating and maintenance costs, on a plane with the efficiency secured in the furnace itself.

Roller bearings applied to rolling stock have assisted materially in producing the desired results. Investigation of various open hearth operations will show that flexible roller bearings have eliminated delays that are inherent in cars equipped with plain bearings.

Steps have been taken in many plants to change to roller bearing equipment gradually by having several cars changed each month. Other less fortunate plants must wait until new rolling stock is required before adoption of the superior type of bearing, on account of new car bodies being required to properly allow for a roller bearing installation. For new open hearth plants, recently built, roller bearings of the flexible type have been specified on the ingot and charging cars.

At first glance, operating men may question the advisability of discarding their plain bearing cars for new ones of the roller bearing type. There must be substantial returns from an investment of this nature. In those plants where plain bearing cars and roller bearing cars are in operation at the same time, it has been definitely established that the saving of the roller bearing over the plain bearing is very marked and returns on the investment are above the average.

During 1917 a comparative test of plain bearing equipped ingot and charging cars and roller bearing equipped cars was made at the Ohio Works of the Car-

negie Steel Company with a dynamometer car. The charts secured from this test showed that the roller bearing equipped train of cars required one fourth the drawbar pull necessary with the plain bearing equipped train. An increased number of charging or ingot cars can be hauled in a train when roller bearings are used, without double-heading with an extra locomotive. It is often necessary to use two locomotives to haul an ingot train from the open hearth pouring floor to the stripper when the plain brass bearings are installed. By applying roller bearings to cars under such conditions the services of this extra locomotive are not required. Noticeable examples of results of this nature are secured at the Youngstown Sheet & Tube Co. and at the South Works of the Illinois Steel Company. The saving in upkeep and maintenance of this extra locomotive will amply pay for the additional cost of the superior type of car bearing.

In the case of charging car installations it has been found advisable to change to the roller bearing in order to haul more cars in a train without purchasing a new

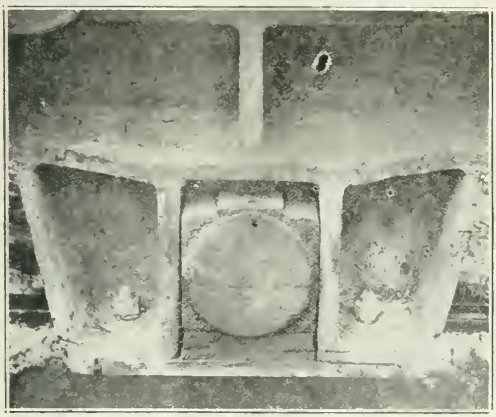


Fig. 1.—Showing simple, compact, protected Hyatt Roller Bearing box for steel mill cars—the outer end of the box is closed except for a small oil hole, and there are no projectingparts or covers to be broken. The whole box can be steadily constructed to withstand the use and abuse that steel mill equipment receives.

locomotive. This change to the roller bearing type of charging or scrap cars can be made economically and is an important matter to consider when a plant secures a shipment of light scrap.

In addition to the return on the investment in the saving of locomotive time, upkeep and repairs to the locomotive, substantial returns have been recorded due to decreased upkeep costs of car bearings and axles.

With cars of the plain bearing type, many brasses are replaced yearly at an astounding cost of replacement. The journal brasses themselves may cost but little but the labor cost and frequency of replacement cause enormous upkeep costs. In some plants brasses are replaced on all cars twice a year while in other plants replacements once each year on all cars are very common. Roller bearing types of ingot mould cars have been in operation at one of the Bethlehem Steel Company plants for over five years and inspection of journals and bearings at the end of four and one-half years service showed no appreciable wear and no cars had been taken into the shops for bearing repairs during that time.

The covers of plain bearing journal boxes are knocked off or left off at the time of lubrication allowing dirt, grit and even hot metal to gain admittance and cause deterioration of the brasses and the axles. Wear of the axle will eventually weaken it to such an extent that a slight shock going over uneven tracks or a blow of an ingot under the stripper crane, will cause a fracture at a time when a delay due to such causes may hold up production on the blooming mill.

The roller bearing journal box can be designed with the outer end closed. No dirt, hot metal or grit can get into the bearing. The lubricant is not burned out but remains in the bearing, where it is circulated back and forth over the bearing surfaces. Journals do not wear excessively and broken axles can be considered a thing of the past.

Another item on which a saving can be effected by the use of the flexible roller bearing is lubrication. Plain bearings require frequent lubrication, very often once each day or before a heat is poured. Experience in many open hearth plants shows that the roller bearing type of car requires lubrication only once each month and cases are on record where lubricant is replenished in the roller

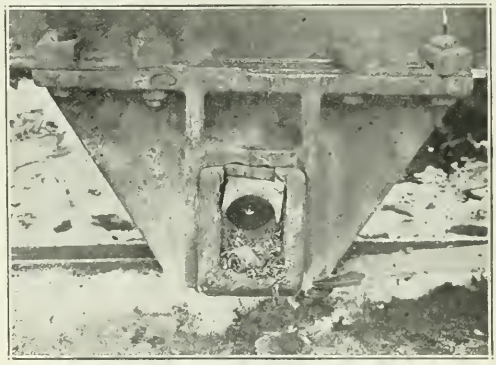


Fig. 2.—Shows graphically some of the disadvantages of plainbearing steel mill cars. The brasses are worn, the protecting cover has been broken, and the boxes full of foreign matter which can but add to friction.

bearings at intervals of two months. Simple but accurate records are easily obtained on lubrication saving by means of a card index system.

With the cars numbered, index cards bearing the car numbers can be made up to show the date the roller bearing cars went into service, the date of inspection and date of last lubrication. The car repair foreman can each day or each week designate certain cars for either inspection or lubrication. The oiler can report the various cars lubricated in a day and this information can be entered on the card. Thus the cost of lubricant and labor per car per week, month or year can be figured up in a few minutes.

With fewer lubrications it will be possible to place some men now used for this work on more important work. One man will be able to take care of several hundred cars when flexible roller bearings are installed on the cars. The labor saving in this connection will vary at different open hearth plants depending on the number of men previously used for looking after the plain bearing equipment.

(Continued on page 635)

Heating Furnaces and Annealing Furnaces

Location and Size of Ports and of Flues—Allowable Velocities—Example Showing Methods of Calculating the Proper Sizes of Stacks.

By W. TRINKS.

PART XXIII.

THE two important questions in connection with ports and flues of a combustion-type furnace are: What is best location of the ports and what should be the size of the flues?

Expressed in general terms, the answer is easy. The ports should be so located that the furnace will absorb the greatest possible amount of heat from the gases of combustion, and the flues must be large enough to carry off the products of combustion, with but little pressure in the furnace, at the greatest rate of heating.

Expressed in specific terms, the answer is more complex. Answering step by step, we see quite readily that outlet ports should be located at a low level, near the hearth, if possible. If the outlet port is located in the roof as shown in Fig. 171, the furnace interior forms a chimney which draws cold air in around the door and through all the cracks, unless the outlet be so restricted that its resistance counteracts the chimney effect. Restriction of the outlet can be accomplished by a damper, but the latter must be manipulated very frequently in order to adapt the resistance of the outlet to the volume of the flue gases. Besides, the flame finds very little surface upon which to "wipe the heat", and the flue gases escape, as a rule, with a temperature considerably in excess of that of the furnace interior.

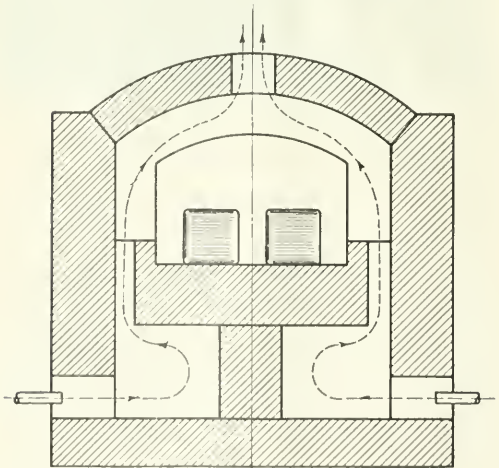


Fig. 171.

If, on the other hand, the outlet port be located at the bottom, as in Fig. 172, then the flame will "lick the hearth". The path of the gases in the furnace is long, so that the gases can give up their excess temperature to the material which is being heated. There should be atmospheric pressure on the hearth, or a very slight excess of pressure, not more than 1/100" of water. The purpose of the flue is not to create any draft in the furnace, but to carry off the products of combustion. The flue must, therefore, be of such size that the draft which it produces is just equal to the velocity head plus the frictional pressure drop of the gases through the flue.

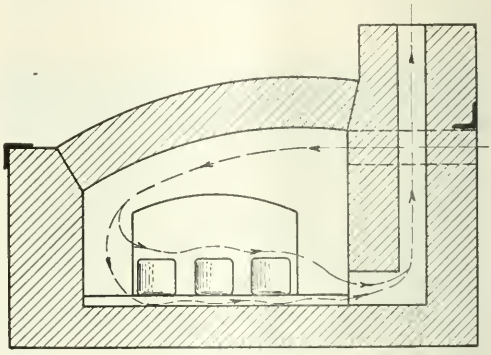


Fig. 172.

The latter requirement presupposes a very delicate balance which is not easily attained or maintained in practice. A way out of this design—and operating—difficulty consists in placing the outlet flues near the door and in making the flue or stack draw too hard. If the flue draws a greater volume than is furnished by the products of combustion, it will suck in cold air through the doors. The cold air serves a double purpose. It satisfies the demand of the stack or flue, without perceptibly cooling the furnace, and it reduces the demand of the stack, by depressing the stack temperature.

Unfortunately, this very good trick is not applicable everywhere, because in long, narrow furnaces, burners and flues must be arranged along the whole length. It is not advisable to discuss right now, the arrangement of the outlet ports, in greater detail, because of the multiplicity of different arrangements which are caused by different fuels, different shapes of materials to be heated and different methods of saving the heat. That discussion will be postponed and will fit much better into the critical comparison of different furnace types which will begin in the January issue.

Turning now to the size of the ports, flues and stacks, we readily recognize that there are two parts to the determination of the proper port size. The first part consists in computing the quantity of the products of combustion and the second part consists in fixing the velocity with which these products of combustion shall flow through the ports and flues.

Determination of the quantity of these products of

combustion leads right back to the problems of capacity and economy of furnaces. A scientifically correct solution of the problem would involve, first, the proper heating capacity of the furnace, and second, the fuel consumption, using the methods explained in parts 1 to 9 of this series. For large, special furnaces that procedure is indeed necessary, but for the ordinary run of commercial furnaces, it is out of the question, because it is seldom known beforehand what quantity and shape of material

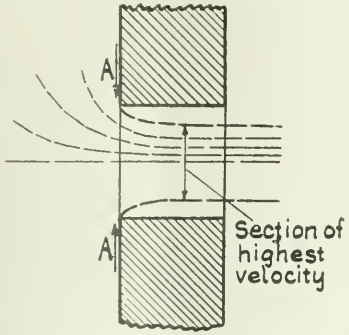


Fig. 173

will be heated in a commercial furnace. For that reason it will pay to derive average figures and to base flue sizes on them. The flues may, in some cases, be too large, but a tile properly placed across the top of each flue will make it right again.

Very few furnaces heat more steel than 100 pounds per square foot and hour. Sixty-five pounds per square foot and hour may be considered a good rate, while underfired furnaces seldom heat more than 35 pounds. The heat requirement of the steel per hour is easily found from this rate and the heat content per pound, see the chart in Part 1. It approximately equals 175 Btu per pound, at 1200 degrees F., 275 Btu per pound at 1600 degrees F., and 375 Btu per pound at 2200 degrees F. On the basis of the very high rate of 100 pounds per square foot and hour, these figures correspond to 17,500, 27,500 and 37,500 Btu per square foot and hour. Radiation losses and convection losses usually equal 15 per cent of these values, except in underfired furnaces in which the losses reach 20 per cent, or even a little more. If the ratio of heat given off by the gases in the furnace to the total heat value of the fuel is called the gas efficiency, then the latter equals about 48 per cent for 2,200 degrees F., 62 per cent for 1,600 degrees F., and 72 per cent for 1,200 degrees F. furnaces (see curves in Part 4). Hence the Btu consumption in the fuel will be $1.15 \times \frac{17,500}{.72} =$ 28,000 Btu per square foot of hearth and hour. for a 1,200 degrees F. furnace, with corresponding values of 48,000 for a 1,600 degree F. furnace and of 90,000 for a 2,200 degree F. furnace. To produce 10,000 Btu by combustion requires roughly 95 cubic feet of air (measured cold). The volume of the flue gases (referred to the same temperature as that of the combustion air) is very little more than that of the air, except in the case of blast furnace gas and producer gas, so that we may figure with 105 cubic feet of flue gas (cold measure) per 10,000 Btu. The ports then have to pass $2.8 \times 105 \times \frac{1200 + 520}{520} = 980$ cubic feet of hot flue gases per square foot of hearth and hour for a 1,200 degree F. furnace. In the same manner we find 2,040 cubic feet per hour for a 1,600 degrees F., and 4,900 cubic feet per hour for 2,200 degree F. furnace.

From these figures the port and flue sizes are easily found, if we know the velocity at which the gases may flow through them. And right here the difficulty begins, if it may be called such. A port which is nothing more than a hole in the roof or side wall offers no other resistance besides the formation of velocity head. For air of atmospheric pressure and temperature a velocity of 100 feet per second requares a head of 2.3" of water. The hotter the air or flue gas, the smaller the pressure which is required to produce a given velocity. Thus we find that 100 feet per second require .7" of water at 1,200 degrees F., .56" of water at 1,600 degrees F., and .44" of water at 2,200 degrees F.

If the pressure in the furnace at the port is not to exceed .01" of water, and if no stack is available to produce a draft, the velocity is limited to $\sqrt{\frac{.01}{.7}} \times 100 = 12$ feet per second at 1,200 degrees F.; 13½ feet per second at 1,600 degrees F.; and to 15 feet per second at 2,200 degrees F. These figures mean the actual velocity and not the so-called average velocity. The latter is about 62 per cent of the highest velocity on account of the inertia of the air or gas particles indicated by the arrows A, Fig. 173, unless the entrance to the outlet port be well rounded. If the gases, instead of simply issuing through the opening into the air, pass into a flue (as is usually the case), then the average velocity is 75 to 85 per cent of the actual velocity at the entrance.

It is evident that "holes in the wall" must be quite large, if they are to take care of the products of combustion, and that the draft created by a short flue or stack is highly desirable. With flue gases at the three temperatures under consideration, the draft produced by a 10 foot stack is as follows: .101" of water for 1,200 degrees F.

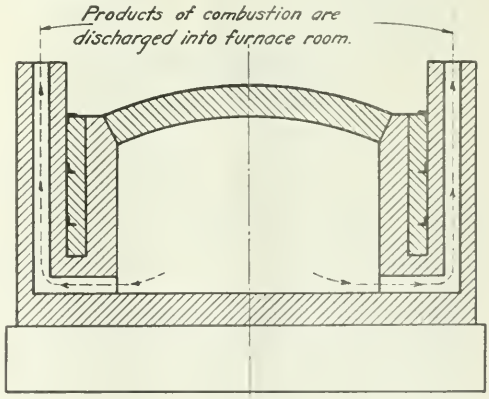


Fig. 174

furnace, .110" for 1,600 degrees F. and .119 for a 2,200 degree F. stack temperature, aside from the reduction of the draft due to frictional resistance.

The problem then narrows itself down to utilizing the available flue height in such a manner that its draft plus the slight pressure in the furnace just balance the velocity

head and the frictional head of the products of combustion.

In most furnaces this equilibrium is attained if we choose an average velocity of 20 feet per second for 1,200 degrees F. furnaces, 25 feet per second for a 1,600 degree F. furnace, and 30 feet per second for a 2,200 degrees F. furnace, see the appendix for theory. On that basis the port and flue area should be $\frac{980 \times 144}{20 \times 3600} =$ 2.0 square inches per square foot of hearth area in a 1,200 degrees F. furnace, $\frac{2040 \times 144}{25 \times 3600} = 3.3$ square in. per square foot of hearth in a 1,600 degrees F. furnace, and $\frac{4900 \times 144}{30 \times 3600} = 6.5$ square inch per square foot of hearth in a 2,200 degree F. furnace. It goes without saying that the flues will be made multiples of brick sizes.

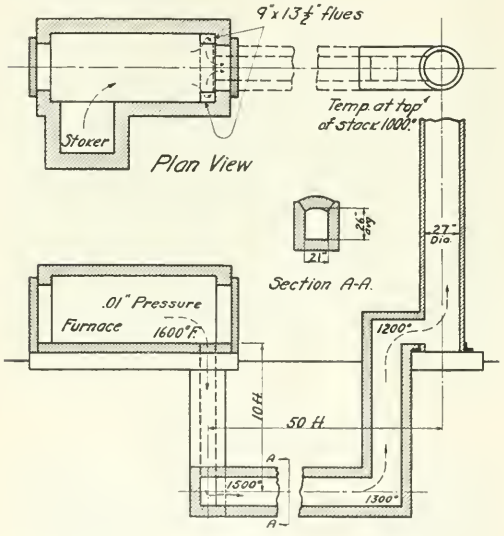


Fig. 175.

These figures need some comment. They were based on a rate of heating 100 pounds of steel per square foot and hour. While this rate is high, the flue sizes figured on the basis of this rate are none too large, because furnaces are frequently fired at or above this rate while heating up from a cold start.

It should also be stated that the above given flue sizes are based on furnaces without regeneration, recuperation, or preheating of steel. Continuous furnaces need only one-third to one-half of the heat per square foot of hearth which is required by "in and out" furnaces, and, besides, cool the products of combustion to a lower temperature (and lower volume) than the "in and out" furnaces do. Outlet port areas in continuous furnaces, for that reason need only be 30 per cent to 40 per cent of the values which were given above.

Properly designed and properly operated regenerative furnaces save 35 per cent of the fuel with a furnace temperature of 2,200 degrees F., and save 24 per cent of the fuel with a furnace temperature of 1,600 degrees F. In 1,200 degrees F. furnaces the saving is very small compared to the cost of installation, and regeneration is hardly ever used. Flues and ports in regenerative furnaces can, on account of the saving, be made smaller in proportion. The flue area then is 4.3 square inch per square foot for 2,200 degrees F. and 2.5 square inch per square foot of hearth in 1,600 degrees F. furnaces.

The products of combustion of producer gas and of blast furnace gas take up a greater volume than those of coal, oil, natural gas, etc. The cold products resulting from producer gas take up 120 cubic feet for every 10,000 Btu liberated, or 1.25 times as much as those resulting from the richer fuels. By comparison with the formerly obtained values, we find for ordinary "in and out", producer gas fired furnaces, 2.5 square inch for 1,200 degrees F., 4.1 square inch for 1,600 degrees F., and 8.1 square inch for 2,200 degrees F. per square foot of hearth area. For regenerative furnaces, these values change to 3.1 square inch for 1,600 degrees F., and 5.4 square inch for 2,200 degrees F. For continuous furnaces using producer gas, use 1.25 square inch for 1,200 degrees F.; 1.8 square inch for 1,600 degrees F. and 3.1 square inch for 2,200 degrees F. per square foot of hearth area.

It should be realized that all of the above given values are average figures, say for furnaces of 40 to 70 square feet hearth area. In smaller furnaces, the port and flue sizes should be somewhat larger (in proportion to the hearth area); while in large furnaces they may be somewhat smaller. The reason underlying this statement is plain. Large furnaces have higher flues and less friction in them in proportion to small furnaces, see the appendix.

As before stated, gas and oil fired furnaces need no stacks. The products of combustion are discharged from a short flue into the open air, see Fig. 174. If the presence of the products of combustion in the workshop is objectionable, a hood with a vent to the roof is the remedy.

Coal fired furnaces, on the contrary, issue objectionable, smoky and sulphurous products of combustion, which are usually discharged through stacks. The proper dimensioning of these stacks seems to be considered a deep mystery. As a matter of fact it is extremely simple except for the regenerative furnaces. As before stated, there must be a slight pressure in the furnace, and the stack has no other function than to carry the products of combustion off. In consequence the stack can be of any height, 15 feet, 25 feet, 40 feet, or whatever is convenient. It is, of course, necessary to carry the stack sufficiently high above the crest of the surrounding buildings to prevent back drafts or eddy currents from blowing down into the stack. The necessity of carrying stacks above the surrounding buildings makes them too high, as a rule; too much draft is produced, and a damper must be used. High temperature dampers are hard to maintain, unless water cooled. The difficulty is obviated by placing the damper on top of the stack, where one side is air-and radiation-cooled. The cross section of the stack is made somewhat smaller than the sum of the cross sections of all exhaust ports, an average ratio being 60 per cent. This reduction is permissible, first, because the gases cool down on the way and take up less volume, and second, because one large duct of a given cross section offers less frictional resistance than many small ducts of the same cross sectional area. Stacks are as a rule, lined with 4½ inch firebrick as a protection against burning out. The smallest practicable brick-lined steel stack is 30 inch diameter of shell. Occasionally a 30 inch stack may be found, but

it requires a "narrow gauge brick layer" to line it. Horizontal flues can be made smaller, because a brick layer can lie in them and work himself away from the lining. It is unfortunate that the same scheme will not work in a stack.

The height of the stack is of importance in some cases. In some instances the stack is located at a considerable distance from the furnace or furnaces. The stack must, in that event, overcome the friction in the horizontal flues, and it must do that work with colder stack gases, because there is some temperature drop in the flues.

It is somewhat risky to explain in a short article the method of calculation of such a case, because it must necessarily vary with local conditions. But the demand for information on this very question has been so insistant that an example will be figured; it is hoped that it will clear up the doubts surrounding the flue-and stack-problem. .

Example: In the furnace represented in Fig. 175, the flue leading to the chimney had to be buried 10 feet deep to pass under a foundation. With regard to draft losses due to friction, the arrangement may be divided into three parts; (1) the two vertical flues 9x13½ inches, 12 feet long; (2) the 21x36 inch flue, 60 feet long, part vertical and part horizontal; and (3) the stack itself.

It should be noted in passing that with this arrangement a door must be provided at the base of the stack; otherwise the furnace could not be started operating normally. By lighting a fire there, draft is produced which is necessary for starting combustion in the furnace itself.

At the start, the equations for draft losses will be stated:

$$\text{Loss of draft due to friction} = .003\,L\frac{C}{A}\frac{C^2}{(t+460)}$$

inches of water.
where

L = length of flue, ft.
C = perimeter of section, ft.;
A = area of section of flue, sq. ft.
c = velocity of gases in flue, ft. per sec.
t = average temperature of the gases in the flue.

$$\text{Loss of draft due to velocity head at entrance} = .184\,\frac{C^2}{(t+460}$$

$$\text{Loss of draft due to a sharp right angle bend} = .165\,\frac{C^2}{t+460}$$

Draft produced by buoyancy of vertical column of hot gases, at average temperature t, height of column H, $\text{ft.} = 7.6\,H\left(\frac{1}{520}-\frac{1}{(t+460)}\right)$ The probable temperatures at various places in the flues must first be set. These can be checked up by finding, (1) the heat loss through the brick walls of the flue, from chart in Part 3 and from the surface area, and by finding (2) how much heat is lost by the weight of gases which pass at the known velocity through the flue, in dropping from the temperature at the beginning to the assumed temperature at end of flue. If the two agree, the assumed temperature is correct.

Heat loss from an underground flue at considerable depth below ground, is not more than one-fourth of that from a flue above ground.

(a) 9″ × 13.5″ flues. L = 12′. C = perimeter = $\frac{(9+13\frac{1}{2})^2}{12} = 3.75$ ft.

A = area = $\frac{9}{12}\times\frac{13}{12} = 8.44$ sq. ft. $\frac{C}{A} = 4.44$

In a 1,600 degree F. furnace, the gases leave at a velocity of about 25 feet per second (see above), or c = 25.

Friction loss = $.003 \times 12 \times 4.44 \times \frac{(25)^2}{(1600+460}$ = .049″ of water

loss in two bends $2 \times .165 \times \frac{(25)^2}{2060} = .100$″ of water

Loss due to velocity head = $.184 \times \frac{(25)^2}{2060} = .056$″ of

Draft due to buoyancy of hot gases in vertical flues = $7.64 \times 10\,(\text{ft.})\left(\frac{1}{520}-\frac{1}{2010}\right) = .109$ in. water

If the pressure in the furnace is + .01″ water, the pressure at the bottom of the vertical flue = + .01 .049 .100 .056 .109 = .304, or the actual draft at the bottom = 3/10 inch of water.

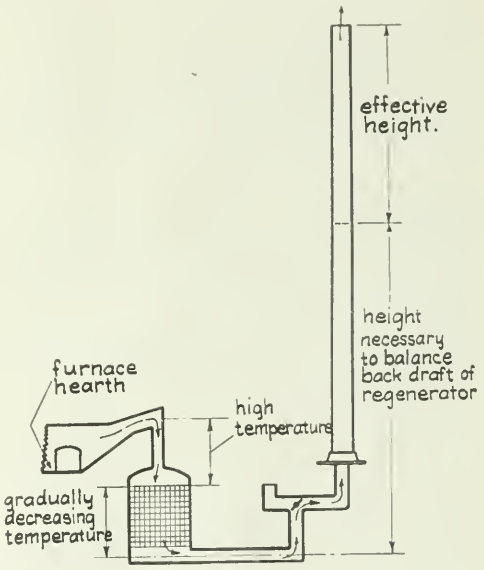


Fig. 176.

In this case the buoyancy of the hot gas column works against the stack draft, increasing the draft at the bottom.

(b) 21″ × 26″ flue. L = 50 ft. horizontal + 10 ft. vertical = 60 ft. A = 3.8, c = 7.7. $\frac{C}{A} = 2.08$. Average temperature = 1350 degrees F.

Average velocity (since the weight of gases is the same as in the 9″ × 13½″ flues but temperature is lower and area greater) is 25 ft. per second × $\frac{2\times.844}{3.8}\times\frac{(1350+460)}{(1600+460)}$ = 9.8 ft. per sec., the volume of a

given weight of gas being proportional to the absolute temperature, which is (t + 460).

$$\text{Friction loss} = .002 \times 60 \times 2.08 \times \frac{(9.8)^2}{1810} = .0198$$

$$\text{Loss in three bends} = 3 \times .165 \times \frac{(9.8)^2}{1810} = .0260$$

Buoyancy of vertical column of gas at 1,350° F. $= 7.6 \times 10 \times \left(\frac{1}{520} + \frac{1}{1810} \right) = .104$

In this case the buoyancy helps the stack draft, but does not quite counterbalance the hotter column of gases in the 9x13½" flues. Pressure at base of stack = .304 .0198 .0264 + .104 = .245". or draft there = ¼" of water.

(c) Stack 27" inside diameter.

In the stack, the buoyancy of the hot gases must balance the sum of the draft at the bottom of the stack plus fractional resistance in the stack.

Area = 3.98 square feet $\frac{C}{A} = 1.78$. Average temperature of gases = 1100 degrees F.

Average velocity =

$$25 \times \frac{2 \times .844}{3.98} \left(\frac{1100 + 460}{1600 + 460} \right) = 8.0 \text{ ft. sec.}$$

$$7.6\ H \left(\frac{1}{520} - \frac{1}{1560} \right) = .245 + .003\ H \times 1.78 \frac{(80)^2}{1560}$$

$$.00979\ H = .245 + .000219\ H$$

$$H = 25$$

Required height of stack = H = 25 ft. above furnace floor level.

Part 2—If the stack must in any case be 60 feet high, to clear surrounding buildings, how small should the underground flue be made?

The additional draft available, deducting friction loss in the extra length of stack, with average temperature in the upper 35 feet of stack = 900 degrees F. and a velocity of $8 \times \frac{(900 + 460)}{(1100 + 460)} = 7.0$ ft. sec., would be

$$7.6 \times 35 \left(\frac{1}{520} - \frac{1}{1360} \right) - .003 \times 35 \times 1.78 \frac{(7.0)^2}{1360} = .310"$$

Draft absorbed by friction in the 21 × 26" flue (see above) = .0198 + .0260 = .0448".

Total draft to absorbed by friction in the smaller horizontal flue = .0458 + 310 = .3558" of water.

Then $.3558 = .003 \times 60 \times \frac{C}{A} \times \frac{C^2}{1810} + 3 \times .165 \frac{C^2}{1810}$.

but $C = \frac{25 \times .844 \times 2}{A} = \frac{42.2}{A}$

and $.3558 = \left(.186 \frac{C}{A} + .495 \right) \times \frac{1780}{1810\ A^2}$,

Simplifying, $.3558\ A^3 = .0457\ C + .487\ A$,

If the flue were made square, calling the side ×, area $A = \times^2$ and the perimeter = 4×. = c.

Substituting, $.3558 \times ^6 = .0457\ (4 \times) + .487 \times^2$,

× = 1.15, or 13½" square.

Instead of using so small a flue, which might become choked and clogged with dust or soot, it would be better to use the 21" flue and install a damper for regulating the draft.

In regenerative furnaces the height of the stack is of greatest importance. The notes in Fig. 176, indicate that the effective height of the stack begins some distance up. The better the regenerator, that is to say, the more heat it abstracts from the products of combustion, the more height is needed to counterbalance the back draft produced by the regenerator, and the lower is the temperature in the remaining "effective" stack. No simple rule can be given for the stack height and diameter on regenerative furnaces. Each stack must be computed individually in conjunction with the furnace, regenerators, and with the flues leading to the stack, including the resistance of the valves. On this type of furnace, many sins of omission and commission are perpetrated rather frequently by copying the design, including the stack, of a successfully operating furnace, while at the same time making changes that would require a higher stack.

Appendix.

The draft produced by a stack of H, feet high, with an average temperature of T° F. (absolute) of the stack gases equals $\frac{39.7}{5.2} H \left(\frac{1}{520} - \frac{1}{T} \right)$ inches of water. The draft loss due to friction in the same stack equals $.003\ H \frac{C}{A} \frac{c^2}{T}$ inches of water, if C = the periphery in feet, A = cross sectional area in square feet, and c = the velocity of the gases in feet per second. The velocity head (taking care of the coefficient of contraction) equals $.184 \frac{c^2}{T}$ inches of water.

Balancing draft against losses, we have,

$$\frac{39.7}{5.2} H \left(\frac{1}{520} - \frac{1}{T} \right) = \frac{c^2}{T} \left(.003\ H \frac{C}{A} + .184 \right)$$

Solve for c,

$$c = \sqrt{\frac{4.96\ (t - 60)}{\frac{C}{A} + \frac{61.3}{H}}}$$ where t = temperature of the stack gases °F., (not absolute)

With this equation the following tabulation was completed.

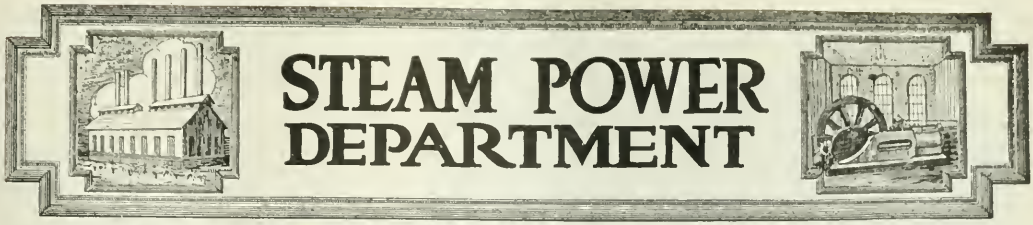
t = °F.	1200°			1600°			2200°		
h = feet	3	8	20	3	8	20	3	8	20
Size of Flue									
4½"x4½"	13.5	17.6	20.3	15.6	20.4	23.6	18.5	24.1	27.8
4½"x9"	14.1	19.0	22.6	16.4	22.1	26.3	19.3	26.5	31.7
9"x9"	14.8	20.9	26.0	17.2	24.2	30.2	20.3	28.6	35.6
18"x18"	15.6	23.4	31.4	18.2	27.2	36.5	21.4	32.1	43.0

The tabulation is very instructive. It shows that for every small furnace (low flue, small cross section) and for low temperatures, the velocity through flues and ports must be low (13 5 feet per second), if excessive furnace pressure is to be avoided. It also shows that in large, high temperature furnaces, velocities up to 43 feet per second are permissible.

LUBRICATING MEN END CONVENTION.

The salesmen and mechanical men of the Keystone Lubricating Company, of Philadelphia, closed a very interesting convention Saturday, October 9, 1920.

Among those present were Harold A. Buzby, Vice President and General Manager; George W. Hall, District Sales Mangager, Pittsburgh District; Warren P. Kline, Pittsburgh District Office Manager; Mr Raub, of the Canuck Supply Co., Montreal, Canada; S. J. Adams, Manager Steel Mill Department.



Draft Combustion and Boiler Stacks

Interdependence of Draft and Per Cent Rating—Draft Loss Through Fuel Bed and Boiler and the Draft Necessary to Produce Velocity of Heat—Forced and Natural Draft.

By F. J. DENK

PART II.

FOR illustrating purposes, a set of curves is shown in Fig. 5. They give the interrelation of the draft losses through a fuel bed for different kinds of coal and different thicknesses of the fuel, all for hand fired furnaces. The curves show that with the increase of the thickness of the fuel bed, that means, with the increase of the rate of combustion, the draft increases. But they show also, that the draft requirements vary with different kinds of coal. There is a marked difference between bituminous slack and run of mine coal on the one hand and the different types of anthracite coal on the other hand. As the first named types contain less carbon than the last named ones, they require less air for combustion. While bituminous coal contains between 50 to 75 per cent total carbon, anthracite contains between 80 to 90 per cent of this constituent. A glance at Fig. 1 of Part 1 of this article (page 575 of last month's issue of the Blast Furnace and Steel Plant), will explain the conditions. For an average of 67½ per cent fired carbon we need approximately 9¼ pounds of air per pound of coal, whereas for an average of 80 per cent fixed carbon we require 11½ pounds of air theoretically for complete combustion. This excess of 2¼ pounds for the latter type of coal has to be forced through the fuel and causes, in turn, the higher draft losses for the anthracite coal.

With stoker installation, when forced draft is applied, the draft losses through the fuel bed do not have to be taken care of by the stack. In these cases, the fan has to overcome the resistance due to the thickness of the fire bed. But as we are considering natural draft here only, we will consider those conditions later on, when we deal with forced or induced draft.

In a boiler draft problem, the draft losses through the fuel bed, or the resistance of the fuel bed, is, under ordinary conditions, the only variable item. For this reason it can be stated, that, as long as the total pressure drop between ashpit and damper remains constant, the weight of the gasess varies inversely as the resistance of the fuel bed, or, in other words, less heat is delivered to the boiler, when the resistance through the fuel bed increases.

The draft losses through the fuel bed are depending, besides on conditions like those illustrated in Fig. 5, on too thick a fuel bed as is suitable for the coal used or on air spaces on the grates filled with slag or air spaces too small for the coal used. These conditions have to be watched carefully and they should be remedied, as the efficiency of the boiler depends to a large extent on them.

The draft through the boiler is another item, which cannot be calculated. It depends upon the type of the boiler, the arrangement of the baffles and tubes and on the load. An increase in the latter means a higher combustion rate, therefore more air and consequently draft. "Steam" gives the following approximate figures: 0.25 inch W. C. for boilers running at rating, .40 inch W. C. for 50 per cent overload and 0.70 inch for 100 per cent overload.

What has been said at the end of Part 1 in regard to curves and tables illustrating the pressure drop through the fuel beds, holds good here also: such tables and curves can be found in many publications. They represent the conditions as obtained by a certain type of boiler or different types of boilers, and, in general, they will only hold good for the conditions and type of boiler, from which they were obtained. From a large number of data at hand, the writer has developed the curve shown in Fig. 5, which is a close average of about one hundred observations, taken principally on B. & W. and Heine boilers, although observations on Cahall and Rust boilers are included. The rated horsepower of these boilers varies between 200 and 400, and, for this reason, the curve may be considered as fairly representative of average working conditions. The interdependence of draft and per cent rating being represented by a straight line, the following formula will hold good for the conditions in question:

where

$d = 0.28 \times L$

d = draft loss through boiler in inches W. C.

L = load on boiler

for instance, for a boiler of the B & W or Heine type we would have for 1½ load, which is equivalent to 100 per cent rating, a draft loss of

$d = 0.28 \times 1.5 = 0.42$ inches W. C.

and for double load or 200 per cent rating

$d = 0.28 \times 2.0 = 0.56$ inches W. C.

for full load, or the boiler running at rated capacity, we would have

$d = 0.28$ inches W. C.

If we compare these figures with those cited above from "Steam", we see that they stick closely for full load and for 1½ load, but that the formula gives a somewhat lower figure for double load than the above named authority.

In case the gases when leaving the boiler do not enter the stack directly, but have to pass through a flue or breeching, this connecting link must be designed in such a way, that it will take care of the volume of the gases passing through it without influencing the draft. For this reason such flues should be designed not with reference to the grate area, but with reference to the quantity of waste gases to be handled. If the flue or breeching has to take care of a number of boilers, leading from them into one stack, it is wrong, to make the flue of an equal cross section all the way through, because the boiler, located next to the stack will get the benefit of the

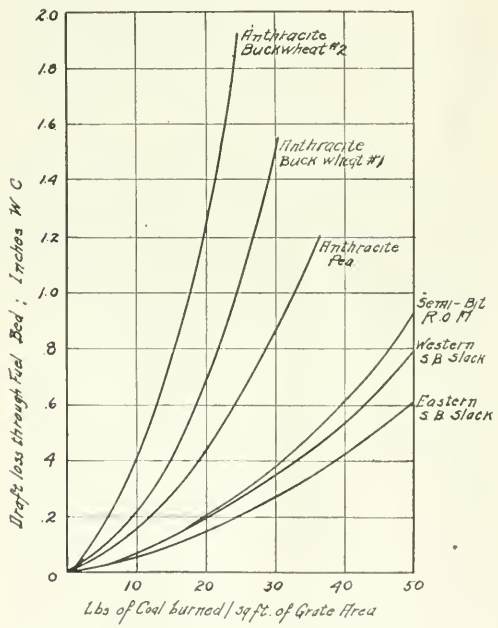


Fig. 5—Draft losses through fuel bed for different kinds of coal and varying rates of combustion. Hand fired grates.

stack draft, while the one farthest away from it will get very little. The writer has seen many an installation of that kind and remembers well a set of five boilers each having a rated capacity of 150 HP and all being connected into one stack, located at the end of the battery. The area of the breeching was of uniform size and the result was a draft at the damper of .75 inches W. C. on the boiler close to the stack and of only .1 inch on the boiler farthest away from it. All dampers being wide open at the time of the investigation, the boiler room superintendent did not know why the last boiler did not work, while the first one worked fine.

The draft loss through the flues or breeching can be determined by the following formula:

where

$$D = \frac{0.008\ V^2}{d}$$

D = draft loss in inches W. C.

V = velocity of waste gases in feet per second.

d = diameter of flue or breeching in feet.

The formula is derived for a length of the flue of 100 feet, for a flue gas temperature of 540 degrees F. and for an atmospheric pressure of inches Hg. For any other length, the result obtained has to be multiplied by 0.01 × the length for any other atmospheric pressure by 30/P where P is expressed in inches of mercury. For any other temperature of the flue gases multiply by 0.001 (t × 460). The density of the flue gases is assumed to be the same as that of air, which is close enough for all practical purposes.

A flue of circular cross-section gives, as can be proven by experience, a smaller draft loss than one having a square or a rectangular cross-section. Bends and sudden changes in cross-section also influence the draft losses. For a right angle bend, having a radius of more than six times the diameter of the flue, the draft loss due to the bend is zero and a sharp right angle bend must be considered as equivalent to 50 feet of straight length.

The last item to be considered in this connection is the draft to produce the velocity through the boiler and grate. This item is usually very small, and it can, for this reason, be neglected in most cases. The amount required can be calculated by the formula

where

$d = .000123\ V^2$.

d = draft loss in inches W. C.

V = final velocity of gases in feet per second.

The initial velocity is zero, as the air can be considered as being stationary in the ashpit. The other conditions, for which the formula hold good, are the same as those for the equation for the draft losses through the flues, viz: a flue gas temperature of 540 degrees F and an atmospheric pressure of 30 inches of mercury. For other pressures multiply by 2/30, and for other temperatures divide by 0.001 (t=460).

The total stack draft is composed of the three items explained in the preceeding paragraphs of

The draft loss through the fuel bed,

The draft loss through the boiler, and

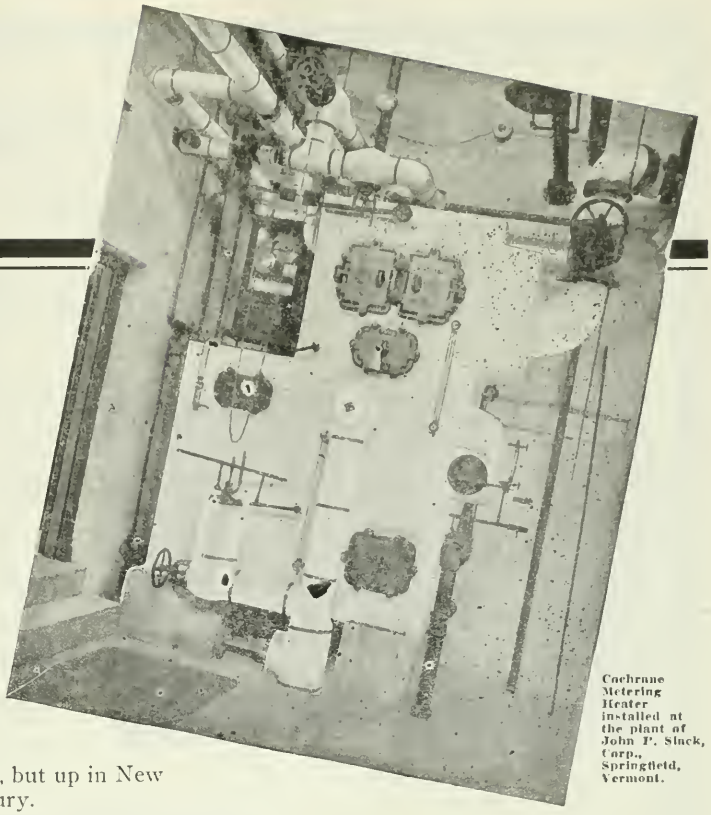
The draft to produce velocity of heat.

Wherever two or more boilers are connected into one stack, another item has to be added to the three mentioned, which is

The draft loss through the flues.

The total draft at the stack should be, under ordinary working conditions, between 0.75 and 1.00 inches of W. C. This statement, however, must not be taken verbally, as, with one and the same stack, the draft may vary on account of different conditions. An increase in the flue gas temperature for instance, will increase the draft. Besides, the draft is greatly influenced by atmospheric conditions: atmospheric pressure, temperature and humidity. Better draft will

The cash register of the coal pile



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This meter, in connection with coal weighing, enables them to detect any falling off in efficiency, as due to accumulation of scale or soot on heating surfaces, defective baffles, leaking boiler settings, inexperienced firemen, inferior coal, defective grates, etc. With the Cochrane Metering Heater the improvement of evaporation resulting from changing methods or equipment is at once demonstrated. For example the best frequency for boiler cleaning can be demonstrated by setting off the cost of cleaning against the value of the fuel saved.

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be obtained with a certain stack on a clear, dry day, than on a hot or foggy day. There is, furthermore, the influence of the wind to be considered. All these different conditions have their effects on the stack draft, although it is hardly possible, that they all occur at the same time,thus aggravating matters, sometimes they may counterbalance each other to a certain extent. Yet, they are there, but they are outside of our determination. We cannot, even approximately, calculate their influence on the draft.

So far, we have dealt with the natural draft only, it being produced, as is well known, by the difference in weight of a column of gases inside the stack and a column of air of equal dimensions outside of it. Mechanical draft, on the other hand, is produced by artificial means. For mechanical drafts, conditions are entirely different from those for natural drafts. The draft losses through the fuel bed and the boiler do not have to be taken care of by the stack, because the fan has to overcome these resistances. In most cases, mechanical draft is applied as forced draft, therefore the pressure in the ashpit is greater than that of the atmosphere. The

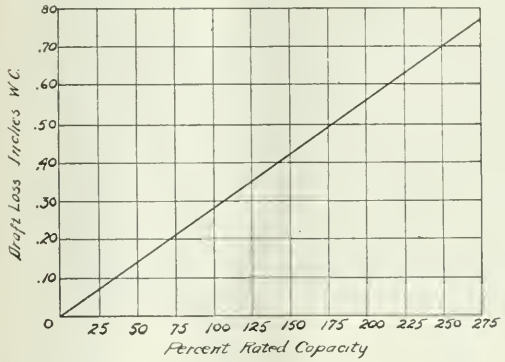


Fig. 6—Curve showing draft loss through boiler for different per cent rated capacity.

advantage of an installation of forced draft over one of induced draft is due to the following conditions. The fan installed for forced draft can be of smaller size than the one supposed to get the same results with an induced draft installation, because the first one has to handle comparatively cold air, whereas the second one must take care of the hot gases of combustion, which means that about twice the volume may have to be moved in the second case compared to that moved in the first case. Besides, with induced draft, the fan has to aspirate the dust and soot coming from the coal and thus might become clogged up or damaged and otherwise causing excessive maintenance cost. With balanced draft, finally, the conditions are such, that the over pressure in the ashpit is just sufficient to overcome the losses through the fire bed, while the draft losses through the boiler proper are taken care of either by the stack or by an induced draft fan. In the latter case, two fans would have to be installed, one for the forced draft through the fuel bed and one for the induced draft through the boiler, the draft on top of the grate or in the rear of the combustion chamber being zero.

Most of the mechanical stokers use forced draft and it may, therefore, be well to say a few words about the general conditions, which should be maintained with such an installation. The stack should be capable of creating a small suction through the entire boiler, because if this is not maintained, the hot gases, being under pressure, might pass out through cracks in the setting or through open doors. In the case mentioned above, where five boilers were connected by a flue of uniform diameter into the stack, and where the last boiler showed very poor working, a forced draft installation was used to overcome the trouble. The grates were of the hand-fired type and, whenever the firemen opened the doors, the flames shot out sometimes three and four feet long. As the men refused to work under these conditions, the superintendent finally agreed to change the flues according to layouts made by the writer and from then on, the boilers worked without giving any trouble, as the gradual increase of the flue toward the stack allowed to reduce the pressure on the last boiler.

The suction is also necessary to permit the regulation of the proper amount of secondary air. The ashpit must, of course, be airtight. The air from the fan must be distributed over all parts of the grate in such a way, that the fire can burn evenly. Care must be taken, that the fan is of proper size, in order to reduce the steam consumption to a minimum. Small, inefficient fans, or small ducts may cause a large steam loss on account of a higher consumption than would be required by an installation of the right size. Two per cent of the total steam generated should be sufficient for a good forced draft fan, but the writer has seen installations, where this figure was far greater. In one case, with a foreign type of mechanical stoker, this figure reacted, at times, 12 per cent, which naturally, caused the removal of the apparatus and the re-installation of the old type.

It was stated before that most of the mechanical stokers work with forced draft. As a rule, all underfeed stokers run with forced draft, whereas chain grate and overfeed stokers mostly use natural draft, unless they are supposed to deliver high overloads. In the latter case they work with forced draft also. For ordinary working conditions the draft loss through the fuel bed for chain grate and overfeed stokers, using natural draft, is 0.25" W. C. Some manufacturers claim between 0.15 and 0.30" W. C. Where forced draft is applied, the pressure in the ashpit varies from 1" to 2.5" W. C. giving a pressure drop through the fuel bed of from 0.50" to 0.75" W. C. As a rule it can be said, that approximately 10 pounds of coal can be burned per square foot of grate area per hour for every 0.1" draft available in the furnace.

For underfeed stokers, running on forced draft, the pressure in the ashpit varies from 0 to 5.5" according to the type of stoker and the conditions under which the boiler is operated. The usual limits are from 1" to 3". With these stokers approximately 1" pressure in the ashpit is required for every 10 pounds of coal burned per square foot of grate area per hour.

(To be concluded)

STAINLESS STEEL FILLS A NEED.

Think of the many practical places where the so-called "stainless" steel can be used to advantage. Even now it is being widely used in the manufacture of pump and valve and valve fittings and similar parts that come in contact with such corrosive elements as water and steam. Surgical instruments and, in fact, the tools of all trades from the finest scientific measuring device, where precision and accuracy require an untarnished surface, to the utensils of the kitchen —all that such extremes embrace offer stainless steel many possibilities.

PRODUCTION TOPICS

YOUNGSTOWN SHEET & TUBE CO.'S PLAN FOR DISTRIBUTING STOCK TO THE EMPLOYES.

President Campbell, of the Youngstown Sheet & Tube Co., has announced the details of its plan for the sale to employes of 100,000 shares of common stock recently set aside for that purpose on the authority of the stockholders.

One-fifth of this amount, or 20,000 shares, is to be offered each year for five years. The price for the first year will be $85 per share, to be paid in installments of $7 per month per share. The number of shares that may be purchased by one employe is limited, the maximum being determined by wages or salary earned, and this maximum being subject to reduction pro rata should the amount set aside for any year be oversubscribed. The largest number of shares for which any employe can subscribe is indicated by the following schedule:

$2,000 or less		5 shares
$2,001	to $2,500	6 shares
$2,501	to $3,000	7 shares
$3,001	to $3,500	8 shares
$3,501	to $4,000	9 shares
$4,001	to $4,500	10 shares

Employes whose earnings exceed $4,500 per year will be entitled to subscribe for stock according to this schedule, with one share added for each $500 above this amount, but in no case will any employe be allowed more than 20 shares.

No cash payment will be required, but $7 per share will be deducted from the wages or salary of the subscriber each month for each share, and this will be credited on his subscription, with all dividends accruing. In cases where wages are paid semi-monthly, $3.50 per share will be deducted from each pay. Interest at the rate of 5 per cent will be charged on deferred payments, but in no case may the interest charged exceed the dividend credited. The first deduction will be from the first pay in January, 1921. The plan provides for full payment of the stock during the year, and employes will be entitled to certain special benefits.

Among these will be a bonus, in addition to regular dividends of $5 per share each year for five years, providing the employe still holds the stock and remains with the company; another will be that in case of death or permanent diability while the subscriber is still an employe of the company, the bonus of $5 per share will be paid on the stock

STATISTICS OF THE AMERICAN IRON AND STEEL INSTITUTE.

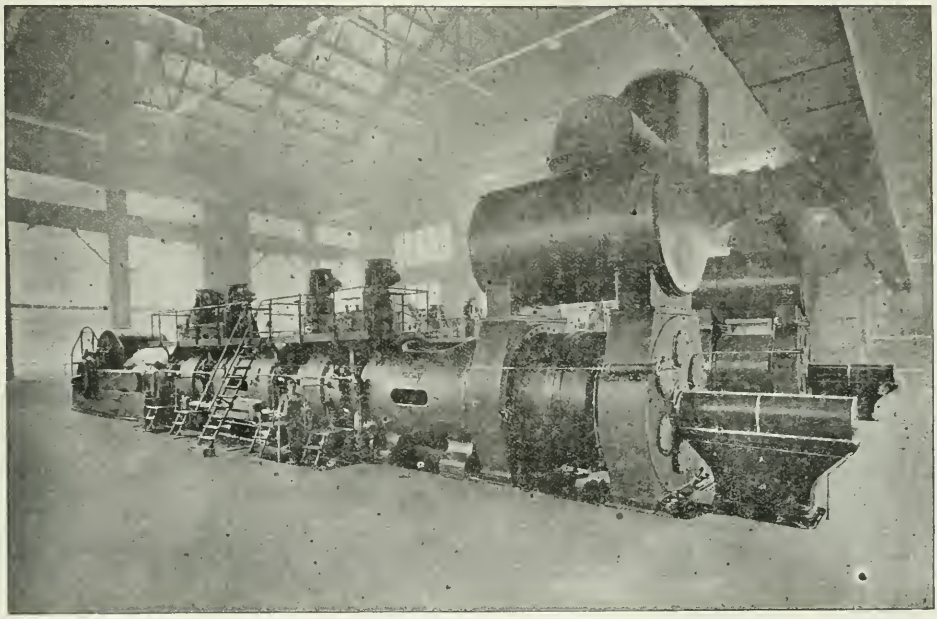
In 1919 the production of all kinds of iron and steel rolled into finished forms (including blooms, billets, and axle blanks rolled for forging purposes and semi-finished products which were rolled for export in that year) shows a decrease of 6,054,210 tons, or 19.43 per cent, as compared with 1918.

Total Production of all Kinds of Finished Rolled Iron and Steel, 1887-1919.

Years	Iron and steel rails	Plates and sheets	Nail plate	Wire rods	Structural shapes	All other finished rolled products	Total Gross tons
1887	2,139,640	603,355	308,432	.....	.....	2,184,279	5,235,706
1888	1,403,700	609,827	289,891	279 769	.....	2,034,162	4 617,349
1889	1,552,204	716,496	259,409	363,851	.....	2,374,968	5,236,928
1890	1,885 307	809,981	251,828	457,099	.....	2,618.660	6,022.875
1891	1,307,176	678,927	223,312	536,607	.....	2,644,941	5,390.963
1892	1,551,844	751,460	201,242	627,829	453,957	2,579,482	6,165,814
1893	1.136,458	674,345	136,113	537.272	387,307	2,104,190	4,975,685
1894	1,021,772	682,900	108,262	673,402	360,305	1,795 570	4,642,211
1895	1,306,135	991,459	95,085	791,130	517,920	2,487,845	6.189,574
1896	1,122 010	965,776	72,137	623.986	495.571	2.236,361	5,515,841
1897	1,647,892	1,207,286	94,054	970,736	583,790	2,497 970	7,001.728
1898	1,981,241	1,448.301	70,188	1,071,683	702,197	3.239,760	8,513,370
1899	2,272,700	1,903,505	85,015	1,036,398	850,376	4.146,425	10.294,419
1900	2,385 682	1,794,528	70,245	846,291	815,161	3,575.536	9.487,443
1901	2,874,639	2,254.425	68,850	1,365,934	1,013.150	4,772,329	12,349,327
1902	2,947,933	2,665.409	72,936	1,574,293	1,300.326	5,383,219	13,944.116
1903	2,992.477	2,599,665	64,102	1,503 455	1,095,813	4,952.185	13.207,697
1904	2.284,711	2,421,398	61,661	1,699,028	949,146	4,597,407	12,013,381
1905	3,375,929	3,532 230	64.542	1,808 688	1,660,519	6,308.107	16.840,015
1906	3,977,887	4,182,156	54,211	1,871,614	2,118,772	7,383,828	19,588,468
1907	3,633 654	4,248,832	52,027	2.017,583	1,940,352	7,972,374	19,864,822
1908	1,921,015	2,649,693	45,747	1,816,949	1,083.181	4,311,608	11.828,193
1909	3,023,845	4.234 346	63,746	2,335,685	2,275,562	7.711,506	19 644,690
1910	3,636,031	4,955,484	45.294	2.241,830	2,206,890	8,475,750	21,621,279
1911	2,822 790	4.488,049	48,522	2,450,153	1.912,367	7,316,900	19,039,171
1912	3,327,915	5,875,080	45,331	2,653,553	2,846,487	9,908,475	24,656,841
1913	3,502,780	5,751 037	37,503	2,464,807	3,004,972	10,030,144	24 791,243
1914	1,945,095	4,719,246	38,573	2,431,714	2,031.124	7,,204,444	18,370,196
1915	2,204 203	6,077,694	31,929	3 095,907	2,437.003	10,546,188	24,392,924
1916	2,854,518	7,453,980	30,088	3,518,746	3,029,964	15,493,093	32,380,389
1917	2,944,161	8,267 616	22,864	3,137 138	3,110,000	15,585,021	33 067,700
1918	2,540,892	8,709,135	18,310	2,562,300	2,849,969	14,385,058	31,155,754
1919	2,203,843	7,372,814	12,832	2,538,476	2,614,036	10,359,543	25,101,544

Rolled blooms and billets for forging purposes are included from 1905, while semi-finished products rolled for export are included for 1912 and subsequent years. Prior to 1892 structural shapes were included in "all other finished rolled products."

MESTA



View showing Mesta Gas Blowing Engines built for The Bethlehem Steel Company.

BLOWING ENGINES

Gas or Steam Driven

The Recognized Standard Among Blast Furnace Engineers.

The Safest and Most Efficient Type of Blast Furnace Blowing Equipment.

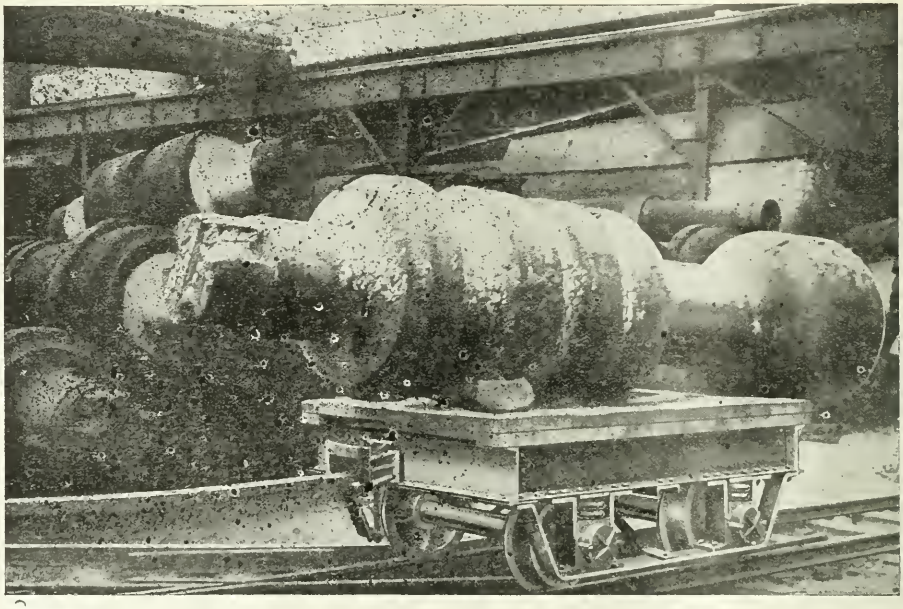
Also Manufacturers of

Gas and Steam Power Engines, Rolling Mill Machinery, Forging Presses, Gear Drives, Air Compressors, Condensers, Rolls, Pinions, Cut and Machine Molded Gears, Iron and Steel Castings, Forgings, Forging Ingots, etc.

MESTA MACHINE COMPANY

PITTSBURGH **PENNSYLVANIA**

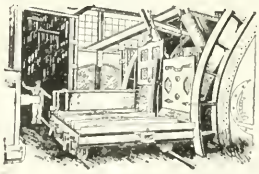
EASTON INDUSTRIAL RAILWAY CARS



Measure Up to the Job

No matter what your internal transportation problems may be—whether raw or finished materials, solids or liquids, hot or cold—or how heavy the load, you'll find Easton Cars and Railway Equipment meeting every condition fully and measuring up to the job.

Easton cars are sturdily built and give long service because they're made of quality materials by competent workmen. When the service requires it, cars are equipped with Easton roller bearings insuring fast, easy traction which means better transportation service with less maintenance and lower motor bills.



CHARGING BOX CARS

We build cars for every steel plant and rolling mill service in both the four-wheel and double-truck, or eight-wheel types of standard and special designs. Platforms made of heavy steel rails when desired.

EASTON ENGINEERING SERVICE

Easton Engineers, with 30 years' experience in designing and building industrial railway systems, will give unbiased advice and make recommendations gratis. Easton Service can furnish every detail from a single car or turntable to complete equipment for the largest plants.

EASTON CAR & CONS'T'N CO.

2077-B

General Offices: 44 Church Street, New York Works: Easton, Pa.

Boston Chicago Detroit Philadelphia Pittsburgh

WITH THE EQUIPMENT MANUFACTURERS

ELECTRIC ARC FURNACE REGULATOR.

High electrode operating speed and close precision of regulation with absolute freedom from hunting are the two important features of the electric arc-furnace regulator just placed upon the market by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Speeds 2½ to 3 ft. per minute, depending upon the amount the quantity being regulated is from normal and 5 per cent precision is claimed.

The ability of this regulator to incorporate high speed with a narrow current zone is due to the fact that the electrode speed tapers all the way from full to zero as the regulated current approaches its normal value. In other words, within certain limits the restoring speed is approximately proportional to the amount the current in the electrode deviates from normal This permits the greatest possible electrode speed for a given current variation. This feature is particularly appreciated during the melt-down of cold scrap. For small variations in current the speed is slow enough to prevent continuous breaking of the arc and at the same time, when the solid metal begins to cave into the pools of molten metal under the electrodes, sufficient speed is available to permit the regulator to extricate the electrode before the time relay allows the breaker to trip. When the current is turned on a furnace charged with cold scrap, it is only necessary to throw the regulator control to the automatic position. Regardless of the position of the electrodes at this time the regulator will allow each one to run down at full speed until it touches the steel when complete automatic regulation will commence. It is absolutely impossible for an electrode to get into the steel, and practically no attention is required from the operating personnel.

One very important feature of the regulator is its utilization of the arc voltage as well as the arc current to control the motors. This device absolutely prevents the electrodes getting into the steel under automatic regulation Under-voltage relay trips on the control circuits are unnecessary. With any purely current actuated device, it is impossible to maintain equal arc lengths in furnaces using two or more electrodes, particularly when operating at reduced power. In the regulator, the arc voltage, as well as the electrode currents, are maintained balanced.

The voltage coils also make the control of each electrode independent of the others in the surface. In fact, one electrode may be entirely withdrawn without disturbing any of the others. In a regular dependent upon current control exclusively, any movement of one of the electrodes causes the elements of all other electrodes to change their positions.

G-R OIL HEATER.

The Griscom-Russell Company, 90 West street, New York, manufacturers of the well known Reilly Oil Heater of the coil type, have recently placed on the market a new oil heater unit of the straight tube type. This is to supplement their coil heater line and is known as the G-R Oil Heater.

INCREASED EFFICIENCY IN THE OPEN HEARTH.

(Continued from page 625)

The advantage of the roller bearing cars are therefore numerous and will vary, depending on present conditions. Greater savings will be possible in those plants where the cars have been in use for several years and where there are a great number of both ingot mould and charging box cars. Operating at 100 per cent capacity an open hearth plant of 12 one hundred ton furnaces will find that yearly returns on an investment for roller bear

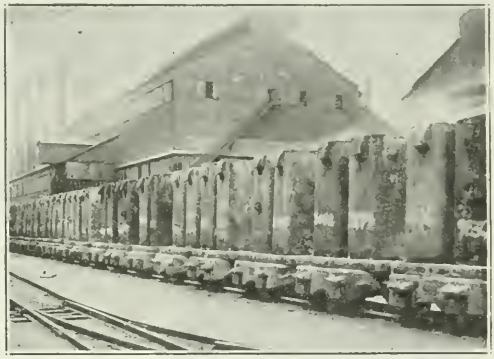


Fig. 3—Some of the Hyatt Roller Bearing equipped ingot cars in operation at the Youngstown Sheet and Tube Company, Youngstown, Ohio.

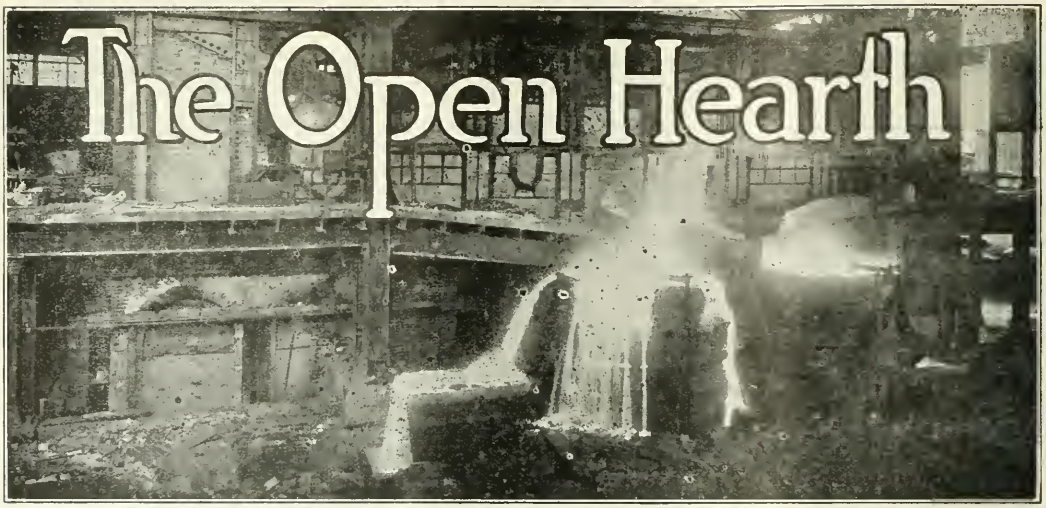
ings amount to at least 35 per cent and often more than this figure when all conditions are considered.

Flexible roller bearings have made possible:

1. Reduction in draw-bar pull required to move a train.
2. Increase in train speed when desired; more rapid handling of trains.
3. Greater number of cars per train without increase in power.
4. Reduced upkeep to locomotives, especially wheel tires
5. Elimination of fires because of closed journal boxes
6. Elimination of wear and breakage of axles.
7. Reduction of bearing replacements to a minimum.
8. Decrease in lubrication frequency to once a month.
9. Decrease in number of car repairmen and men required for lubricating car bearings.
10. General speeding up of production from the open hearth to the blooming mill via stripper and soaking pits

Users of Open Hearth Cars Equipped With Flexible Roller Bearings.

Carnegie Steel Company, Farrell, New Castle, Youngstown, Mingo Junction, Braddock, Bellaire; Bethlehem Steel Company, South Bethlehem, Lebanon, Sparrows Point; Illinois Steel Company, Gary, South Chicago, Joliet; Canton Sheet Steel Company; Central Steel Company; Cromwell Steel Company; American Sheet & Tin Plate Co.; Heppenstall Forge & Knife Company; Mansfield Sheet & Tin Plate Co.; Lukens Steel Company; Central Iron & Steel Co.; Keystone Steel & Wire Co.; Trumbull Steel Company; Tennessee Coal, Iron & Railroad Co



PROMINENT LUBRICANT MANUFACTURER CLAIMED BY DEATH.

Augustus C. Buzby

Augustus C. Buzby, well known manufacturer and clubman, passed to his final rest on Tuesday, September 21. He was president and founder of the Keystone Lubricating Company, one of the largest manufacturers of lubricating oils and greases in the world. Was regarded as being a representative man of affairs and is mourned by a wide circle of friends and acquaintances.

It is with a feeling of sorrow that the community at large will look upon the completed chapters of a life so full of energy, so concerned in the city's success and so interspersed with noble deeds reflecting a perpetual credit upon Mr. Buzby. He was a man who made and held friends because he possessed those qualities which endear a man to his fellows, and the record of his life and its accomplishments may be had as an example to be followed by members of the rising generation.

Mr. Buzby, who was sixty-six years old, was born in New Jersey. He was a descendant of an old Quaker family, which dates back to 1606 in England, which settled in Burlington county, New Jersey, in 1640. He came to this city while a youth, and attended the Philadelphia College of Pharmacy. After his graduation from that institution he engaged in chemistry, and subsequently organized a wholesale drug supply business, which he conducted until he founded the Keystone Lubricating Company, of which company he was president and founder. The headquarters of the company, which is one of the largest manufacturers of lubricating oils and greases in the world, are located at Twenty-first, Clearfield and Lippincott streets, Philadelphia. He has always made it a cardinal point to advance and promote the interests of patrons in every possible manner, and his square deal methods of business were instrumental in developing a large and important trade.

Mr. Buzby was one of the oldest members of the Manufacturers' Club and during his younger days took an active interest in the affairs of the club. He was also a member of the Philadelphia county, Pen and Pencil, Friendly Sons of St. Patrick, Terrepin and other clubs, and was a prominent Mason.

He was a vestryman of the Episcopal Church of the Savior. He is survived by his widow, Mrs. Florence Buzby and four sons, to whom the sympathy of the entire community is tendered in the hour of their deep bereavement. His funeral took place from his late residence, 4528 Spruce street, on Friday, September 24. Services were conducted at the house of the Rev. Dr. Robert Johnson and the Rev. Julius G. Bierck, and the interment was made in West Laurel Hill Cemetery.

Although the business community will learn with regret of the death of Mr. Buzby, at the same time it is gratifying to know that his passing away will in no way effect the business of the Keystone Lubricating Company, which will be continued under the management of the surviving officials, Harold A. Buzby, vice president and general manager, Warren F. Buzby, second vice president and treasurer and Norman F. Buzby, secretary and export manager, Kenneth K. Buzby, assistant treasurer, sons of the deceased who are all conversant with every detail of the business.

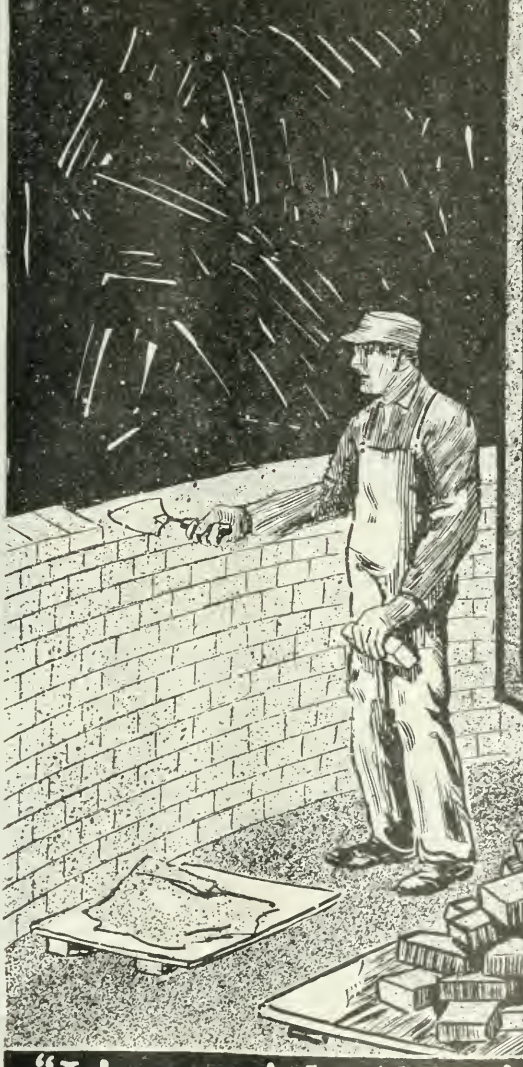
V V

Albert J. Maheu has accepted the position of purchasing agent of the Republic Rubber Company, Youngstown, O. Mr. Maheu was formerly superintendent of the Morgan works of the Wickwire-Spencer Steel Corporation, Worcester, Mass.

V V

LeRoy Richards has become associated with the sales depart-

ASHLAND FIRE BRICK



FIRE Brick linings, to exert the necessary resistance to the action of destroying influences in the process of smelting must be compounded with a view to resisting the conditions such as the finished work will meet.

Various grades of fire brick meeting these conditions cannot be equally successful. Differences in compounding will effect the fusion point and cause decided physical changes.

Getting the right fire brick for the specific condition is about the same as buying specification steel. Analysis means much. So with fire brick, Ashland Steam Pressed Fire Brick meet the requirements of furnace service successfully. They are highly refractory—non-Vitrifiable in service, contain maximum weight for standard size brick and are smooth, with no lamintations.

Why not investigate the Ashland line of High Temperature Fire Brick?

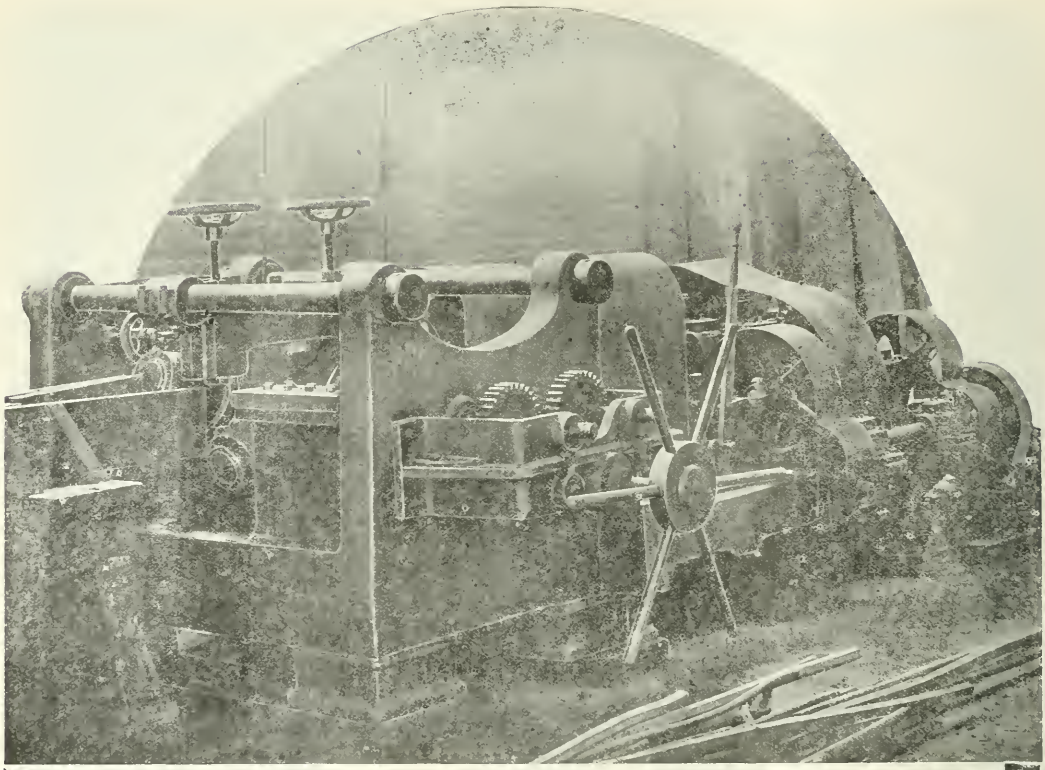
Ashland Fire Brick Company

Ashland, Kentucky

Established 1886

"Line with the Ashland Line"

Co-operate:—Refer to The Blast Furnace and Steel Plant



MEDART

Continuous Automatic Bar Straighteners

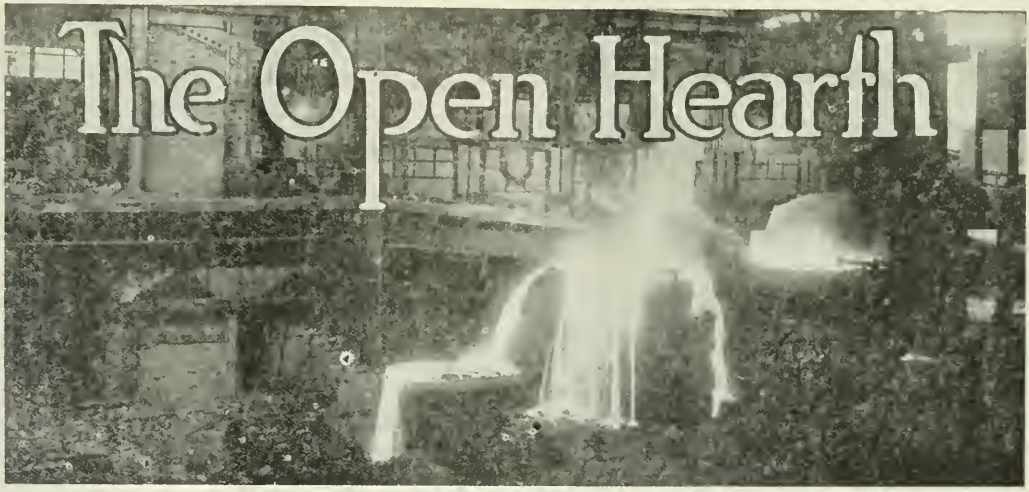
Save time, labor and money by straightening, polishing and cold rolling bars in one operation. Medart straighteners operate continuously, one bar following another as closely as possible. The entire bar passes through the rolls, applying full pressure on the bar to the extreme end. This overcomes the difficulty that has been experienced with other machines and removes crooks near the ends of the bars

Write for Medart Catalogue.

MEDART PATENT PULLEY COMPANY

ST. LOUIS MISSOURI

"To get the Right Start Equip with MEDART"



ment of the Alan Wood Iron & Steel Co., Philadelphia, Pa. Mr. Richards was Philadelphia manager of sales for the Nagle Steel Company for some time.

Maj. R. A. Bull, who recently resigned from the Duquesne Steel Casting Company, Coraopolis, Pa., of which he was vice president, has been employed by a group of six steel casting manufacturers in the capacity of consulting metallurgist and for the primary purpose of developing higher standings in the foundries operated by these manufacturers. The members of this group of steel casting producers are as follows: Electric Steel Company, Chicago; Fort Pitt Steel Casting Company, McKeesport, Pa.; Isaac G. Johnson & Co., Spuyten Duyvil, N. Y.; Lebanon Steel Foundry, Lebanon, Pa.; Michigan Steel Castings Company, Detroit; and Sivyer Steel Castings Company, Milwaukee.

A. E. Murdock has been appointed assistant manager after being tool room foreman for the past 18 months of the Elmwood branch, Hartford, Conn., of the New Departure Manufacturing Company, Bristol, Conn.

J. Chilbert has retired as vice president of the Colorado Fuel & Iron Co., Denver, Col., under the terms of the company's service retirement plan on account of ill health. A. H. Lichty has been appointed vice president in which capacity he will devote his attention exclusively to matters bearing on employes representation and conditions affecting employment. E. S. Cowdrick has been appointed assistant to Mr. Lichty and will continue as editor of the company's industrial bulletin and will assume increasing responsibility in connection with employes' representation. Fred Farrar has been appointed executive assistant to President J. F. Welborn and will continue as general counsel and secretary.

N. P. Whitaker and W. H. Abbott recently were elected vice presidents of the Whitaker-Glessner Company, Wheeling, W. Va., a subsidiary of the Wheeling Steel Corporation.

E. J. Jeffries of the Canada Steel Company, Hamilton, Ont., was elected president of the Association of Iron and Steel Electrical Engineers at the organization's annual dinner held in New York. Mr. Jeffries succeeds B. W. Gilson of the Youngstown O., works of the Carnegie Steel Company.

William A. Hitchcock, Charles L. Taylor, George H. Sage and Philip B. Gale have been elected as an executive committee of the Collins Company, Collinsville, Conn., maker of edge tools, by the directors, succeeding Meigs H. Whaples and Charles H. Clark, resigned. William Hill, president ex-officio, is a member of the committee. Mr. Whaples is secretary and treasurer of the company.

G. R. Delamater has resigned his position as assistant superintendent of coke ovens at Steelton, Pa., to become vice president and general manager of the Anthracite Production Corporation, which has rights to reclaim anthracite coal from the Susquehanna near McCall's Ferry. Frank D. Carney and L. B. Lindemuth, of New York, are associated with Mr. Delamater.

Horace S. Wilkinson, chairman of the Crucible Steel Company, has been elected a member of the board of directors of the National City Bank of New York to serve for the remainder of the year.

H. H. Sutton of Pittsburgh, recently became general manager of the Hubbard Pressed Steel Company, Niles, O., to succeed Frederick Maples. N. A. Ormes has retired as the company's plant superintendent.

L. E. Taylor accepted a position as assistant to the president of the Woodard Machine Company, Wooster, O. Mr. Taylor was formerly private secretary to H. L. Rownd, vice president of the Republic Iron & Steel Co., Youngstown, O., and also served 12 years under L. A. Woodward's direction when he was general manager of the William Tod Company, Youngstown.

L. MacKenzie has resigned his position as general manager, treasurer and director of the newly formed Louisville Steel Company, Louisville, O., to engage in other business. J. W. Lucas, secretary of the Louisville Steel Company since its organization, will succeed Mr. MacKenzie. Mr. MacKenzie was formerly connected with the corrugating plant of the Canton Sheet Steel Company, as general manager for six years; also, he was in charge of this kind of work at the plant of the Berger Manufacturing Company for 13 years.

NEWS OF THE PLANTS

The Cambria Steel Company, Johnstown, Pa., is continuing its improvement program at its local plant, and has awarded a contract to the Arthur G. McKee Company, Cleveland, O., for the construction of a new three-story sintering plant, 60x172 feet, to cost about $500,000.

The American Car & Foundry Company, 165 Broadway, New York, has awarded a contract to the Gillespie & Daly Co., International Life Building, St. Louis, Mo., for the erection of a one-story addition to its works at Madison, Ill., to be equipped for the manufacture of steel springs. The structure will be 70x160 feet, and is estimated to cost about $50,000. S. S. Eagle is local superintendent. At its Buffalo, N. Y. plant, the company has completed plans for the construction of a two-story addition, 46x75 feet, to cost about $40,000.

The Louisville Sheet Steel Company, Louisville, Ky., is planning for early occupancy of its new local plant, now in course of erection. The new works will specialize in the production of sheet products of various kinds, including galvanized equipment. James Fraunfelter is president of the company, and J. W. Lucas, secretary and sales manager.

The Topeka Foundry & Iron Co., 318 Jackson street, Topeka Kan., is planning for the construction of a new iron works, and will select an architect at an early date to prepare plans and specifications. The plant will consist of a number of buildings and is estimated to cost about $100,000, including equipment installation.

The Carpenter Steel Company, Reading, Pa., has awarded a contract to the Beard Construction Company, 658 Penn street, Reading, for the erection of a new one-story addition to its plant, 35x80 feet, to be equipped as a pickling works. It is proposed to inaugurate construction immediately.

The Tredegar Iron Works, Fifth street, Richmond, Va., is arranging for the immediate rebuilding of the portion of its plant recently destroyed by fire, with loss including equipment, estimated at about $200,000, including machinery. The company specializes in steel casting work, and during the war period devoted operations to shell production.

The Steel Fabricating Corporation, Harvey, Ill., is planning for the erection of a new plant for large increased capacity. A site comprising about 40 acres of ground has been acquired at Michigan City, Ind., with water front facilities, and it is proposed to inaugurate work on the project at an early date. As soon as the new buildings are ready for service, it is understood that the present plant will be removed to this location.

The Missouri Car Company, Central National Bank Building, St. Louis, Mo., recently formed with a capital of $500,000 to operate a steel works for the manufacture of street railway trucks and cars, has plans under way for the proposed plant. A local site has been acquired. The main building will be 100x400 feet, and will be supplemented by a number of smaller units. A large power plant for works operation will also be constructed. The initial production will comprise cars of one-man safety type, with plant output of about 10 cars per week. The company is headed by Theodore A. Brewster, president; J. J. O'Brien, vice president and treasurer; and G. E. Holke, secretary. The plans for the project will be prepared by Eames & Young, architects, Arcade Building, St. Louis. Brussel & Viterbo, Arcade Building, St. Louis, are consulting engineers.

The Stanley Steel Wheel Company, Boston, Mass., has perfected plans for the erection of its proposed new plant at Tonawanda, N. Y., and will inaugurate construction at an early date. The company recently acquired a large site at this location. The initial units of the proposed works will cost in excess of $75,000.

The D. P. Dunn Structural Steel Company, Standard Life Building, Pittsburgh, Pa., has completed plans for the erection of a new plant at Hoboken, Pa. The structure will be 75 x 150 feet, and will be equipped as a steel fabricating works.

The Sharpsville Boiler Works, Sixth Street, Sharpsville, Pa., manufacturer of boiler plate, structural steel shapes, etc., has plans under way for the erection of an addition to its plant for increased production. It is planned to inaugurate construction at an early date.

The Concrete Steel Company, 42 Broadway, New York, has completed plans for the erection of a new steel fabricating plant at Cleveland, Ohio. The structure will be one-story brick and steel, and with equipment installation is estimated to cost about $200,000.

The Iron City Pipe & Foundry Company, Birmingham, Ala., manufacturer of pipe, steel castings, etc., has plans under way for the erection of four new plant units at its works for increased production; the structures, with equipment are estimated to cost about $300,000.

The Stalium Metals Corporation, Chester, Pa., a new corporation formed under Delaware laws with capital of $2,500,000, to manufacture steel products, is planning for the erection of a new plant on local site, recently acquired. The property consists of about 10 acres of land in the western section of the city, near the works of the American Steel Foundries. Preliminary plans are under way for the initial buildings of the new steel works, which will occupy about one-fourth of the site. Upon completion, it is proposed to build a number of other plant units. The company is headed by S. S. Staley, president; Edward F. Gray, vice-president, connected with the Bethlehem Steel Company, Bethlehem, Pa.; Dr. J. J. Mullowney, Girard College, Philadelphia, Pa., secretary; and Edward Stout, treasurer.

The Direct Steel Process Company, San Jose, Cal., a new organization, is planning for the erection of a plant on a local site. Negotiations for property are understood to be under way, and preliminary plans for the new plant are being prepared. The company is headed by Robert Lang, Oakland, Cal.; Charles H. Walsh and W. J. Johnston, San Jose.

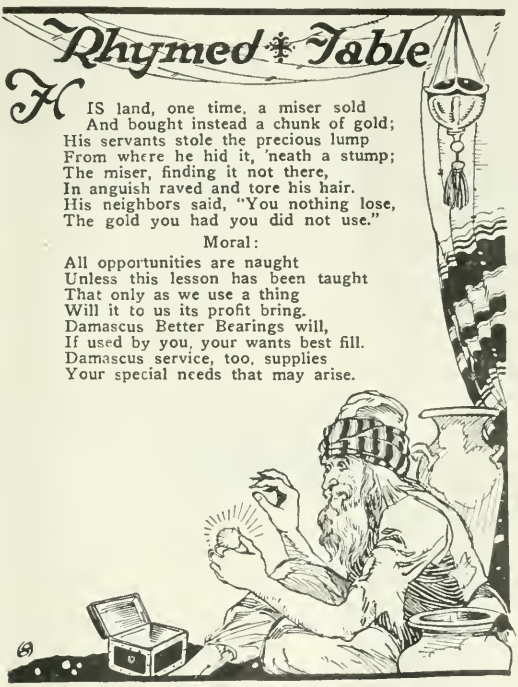
The Baltimore Malleable Iron & Steel Casting Co., Charles St., Baltimore, Md., has plans under way for the erection of additions to its plant for increased production.

Rhymed Fable

HIS land, one time, a miser sold
And bought instead a chunk of gold;
His servants stole the precious lump
From where he hid it, 'neath a stump;
The miser, finding it not there,
In anguish raved and tore his hair.
His neighbors said, "You nothing lose,
The gold you had you did not use."

Moral:

All opportunities are naught
Unless this lesson has been taught
That only as we use a thing
Will it to us its profit bring.
Damascus Better Bearings will,
If used by you, your wants best fill.
Damascus service, too, supplies
Your special needs that may arise.



Ask for information and quotations on Bearings for every purpose.

DAMASCUS BRONZE CO.
PITTSBURGH

An installation of Koppers Triangular Flued Combination Coke and Gas Ovens is the logical one for any Steel Company that must supply an adequate Gas Supply in addition to a reliable source of high grade Coke.

THE KOPPERS COMPANY

PITTSBURGH, PA.

Designers and Builders of By-Product Coke Plants

Some Pointers on By-Product Coke Oven Operations

Various Producer Gas Operations for Coke Oven Heating.

In considering the economic operation of gas producers in connection with by-product coke ovens, several possibilities present themselves, which, when considered in the light of the potential economic advantages, is one of many arguments in favor of building every by-product coke plant so that producer gas may be used at any time for heating the ovens if desired

This subject has been discussed at some length in a paper by Joseph Becker and F. W. Sperr, Jr., recently presented before the Blast Furnace and Coke Association of Chicago, and the principal arguments are taken from this paper.

First, the producers may be fed with small sized coke unsuitable for use in the blast furnaces. Here the equipment is simple and comparatively inexpensive, especially with respect to the gas cleaning apparatus. The amount of coke required for the producers is 12 to 14 per cent of the weight of the coal charged into the ovens. This amount may readily be obtained by properly screening the oven product, leaving a high grade, thoroughly clean coke for the use of the blast furnaces.

Second, where there is available a cheap coal, having fair coking qualities, but unsuitable for the manufacture of blast furnace coke, such coal may be coked in some of the by-product ovens, delivering, thereby, its by-products and furnishing sufficient coke for the operation of the gas producers.

Third, where there is available cheap low grade coal unsuitable for making blast furnace coke, such material may be used directly in the gas producers.

Fourth, by-product producers may be installed using any coal available. The equipment and operation of by-product producers fits in very well with that of the by-product coke plant, and the combination, costing much less than separate plants, offers many possibilities for increased economy and valuable returns. Heretofore, on account of coal values, the employment of by-product gas producers has been more extensive in Europe than in America, and here, with the present appreciation of coal values, their development presents enormous possibilities

The Kerpely Gas Producer.

The type of producer conspicuous in European use in connection with by-product ovens and elsewhere is the Kerpely producer The Koppers Company controls the American patent rights on this type of producer and is actively adapting it to American conditions for its by-product coke oven operations and in connection with by-product producer plants. The next few years will witness much important progress along this line.

Economic Changes Favoring Coke Oven Gas.

The situation is that, on the one hand, the development of the gas producer, whether using coal or coke in connection with by-product coke ovens, together with the successful and advantageous application of producer gas to oven heating, are such as to offer the strongest inducements for this method of heating; while on the other hand, the demand for high grade gas is increasing so that every by-product coke plant in the country is, sooner or later, going to be required to render available every cubic foot of coal gas that it makes

It is eventually going to be considered rank inefficiency for any plant to use this valuable gas for the purpose of heating its ovens, which purpose could even be better served by lower grade gas. These requirements are going to be brought about by the increasing shortage and cost of good coal, the increasing shortage of natural gas and fuel oil, and by the advantages of coke oven gas over lower grade gases from the various standpoints discussed. In the face of this, it is plain that every new battery of by-product coke ovens built in connection with a steel plant or blast furnace ought to have provisions so that, at any time, producer gas equipment can be added to the plant and so that the ovens can be heated either with this gas or with blast furnace gas

Combination Oven and Its Relation to Future Developments.

Suppose that, in the case of a given projected plant, it might possibly appear, on the face of present financial returns, that there would be no marked present gain from the installation of gas producers in connection with the coke ovens. Nevertheless, assuming that the life of a battery of modern coke ovens is from 10 to 15 years, and in view of the great economic and engineering progress possible in the life of such a plant, one should hesitate to commit himself to building plain coke ovens, which would practically require rebuilding before they could use producer gas economically. The use of producer gas or blast furnace gas might well be advantageous a few years hence, if not now. The building of combination ovens is, in effect, providing insurance against future contingencies at relatively low cost and with promise of large returns.

As a further consideration, it should be pointed out that the combination oven can be heated with blast furnace gas as well as with producer gas, and under certain conditions, this method of heating has the advantage of requiring very small expense for equipment to release large quantities of high grade coke oven gas.

Geographical Considerations.

It is a striking fact that the great majority of by-product coke plants have a most fortunate location, with respect to the advantageous disposal of the gas that they produce. The locations, too, are remarkably fortunate when considered in connection with natural gas interests. Table 2 has been prepared to show the number of by-product coking plants that are grouped in, or within convenient reach of seven great industrial districts, viz.

1. The Chicago and Milwaukee district, including Joliet and the great plants at the southern end of Lake Michigan.
2. The Detroit and Toledo district.
3. The Cleveland and Pittsburgh district, including the plants at Youngstown, Steubenville, Johnstown, and as far south as Fairmont, W. Va.
4. The Buffalo district.
5. The eastern Pennsylvania district, including the plants near Harrisburg, South Bethlehem, and Philadelphia.
6. The Birmingham district, extending north to Gadsden and south to Tuscaloosa.
7. The Ohio River district, lying between Cincinnati and Wheeling

The table shows the number of ovens in each district and the estimated maximum capacity for coking coal and manufacturing gas This maximum rated capacity will, of course, never be reached, and a factor of 80 per cent may be used to represent normal operating conditions. The list includes plants in construction May 1, 1920, as well as the plants that are in regular operation

TRADE NOTES

The R. H. Beaumont Company, of 319 Arch street, Philadelphia, contractors for conveying and hoisting systems and complete power plants, have recently opened a Pittsburgh, Pa., office at 230 Fifth avenue. Mr. Thomas Widdop is in charge.

R. D. Nuttall Company, manufacturers of gears, pinions and flexible couplings has equipped new and permanent quarters at 429 Title & Trust Building, Philadelphia, Pa., to handle direct all business other than electric railway and mine haulage supplies. This office will be a direct Nuttall office and will be in charge of R. F. Fiske.

The Armstrong Cork Company of Pittsburgh, have issued a new publication on "Nonpareil Insulating Brick," a 72-page book on the insulation of high temperature industrial equipment, such as boilers, furnaces, stills, hot blast stoves, ovens, kilns, etc.

While dealing particularly with the description of Nonpareil Brick and their uses, the book is more than a catalog. The subject of heat insulation has been thoroughly studied from both the theoretical and practical standpoints, and the results here compiled contribute to make this book a really valuable and instructive treatise. It is conveniently divided into sections, each dealing with a particular type of industrial apparatus so that anyone can readily find the data for the equipment in which he is especially interested. Operating records, with and without insulation, are given, actual dollars and cents savings demonstrated, and the economy and advantages to be secured by the use of Nonpareil Brick described in a most interesting and convincing manner.

The book is attractively and substantially bound and profusely illustrated. Its subject matter is of such vital importance to all industries employing high temperature equipment, that plant managers, superintendents and engineers will find it a valuable addition to the technical library.

The Electric Furnace Construction Company, 608 Chestnut street, Philadelphia, advise the successful starting up of new "Greaves-Etchells" Electric Furnaces at the Vancouver Engineering Works, Vancouver, B. C., and Sullivan Machinery Company, Claremont, N. H.

The Electric Alloy Steel Company, Youngstown, O., is proceeding with the construction work on the extensions to other improvements at the Charleroi, the electric furnace department and Pa. plant, and contracts have been let for piling, concrete work, buildings, cranes, motors, etc., but some equipment still remains to be bought. Barton R. Shover, Oliver Building, Pittsburgh, Pa., is the consulting engineer for this work as well as for the plant which this company proposes to build in the near future at Niles, O.

The Lancaster Steel Products Corporation, of Lancaster, Pa., have just recently opened a New York office in the National Association Building, at 25 West Forty-third street. The office is in charge of L. E. Vesey, as district sales manager. Mr. Vesey comes to New York from the Chicago office, where he has been engaged for the past year and a half. This office together with the Hartford, Conn., Detroit and Chicago offices, will enable Lancaster Steel Products Corporation to more adequately take care of their rapidly growing business in the cold rolled and cold drawn field.

The Westinghouse Electric & Manufacturing Co. has added a new foundry building, 120 ft. by 200 ft. to their South Philadelphia works. The architecture of the building is of "daylight" design with the sky light glass beginning about 3 feet 7 inches from the ground and extending over the entire building which at the highest point is about 26 feet.

This foundry will be used to make castings that weigh a half pound upwards to one-half ton. The larger castings, weighing from one-half ton upwards to 150 tons, will continue to be made in the large foundry, 650 feet by 187 feet.

The new foundry was erected to help take care of the new shops that were recently completed, namely, Machine Shop No. 3, which adds 130,000 square feet, and the 300 foot extension of the erecting shop, now an 850 ft. by 125 ft. building, with a balcony of the extreme length, 42 ft. wide.

Other additions recently finished are: A three-story warehouse, with 86,650 sq. ft. of floor space; two pattern storage buildings, 30 ft. by 256 ft. and two garages that accommodate a total of 60 automobiles. The new extensions will practically double the employed force which now number 3,500.

TRADE PUBLICATIONS

"Steel Mill Control," is the title of a new 48-page 8¼x11 booklet, with a two-color cover, published by Cutler-Hammer Manufacturing Company, of Milwaukee, Wis. The booklet tells briefly the story of iron and steel, from the ore in the mine to the finished product of the steel mill, and explains how Cutler-Hammer products have aided in making possible the great engineering progress in mining and ore handling, and in furnace and steel mill practice. The booklet is profusely illustrated with C-H controls and other products as well as views of their installation. Every machine peculiar to the steel industry is referred to, with a discussion of the control to be used. One of the most ingenious devices shown is an automatic controller for the gas cock reversing mechanism for coke ovens. This apparatus operates under the direction of a self-winding master clock and at predetermined time intervals three different valve operations are performed in a definite sequence. About 40 other controls are described.

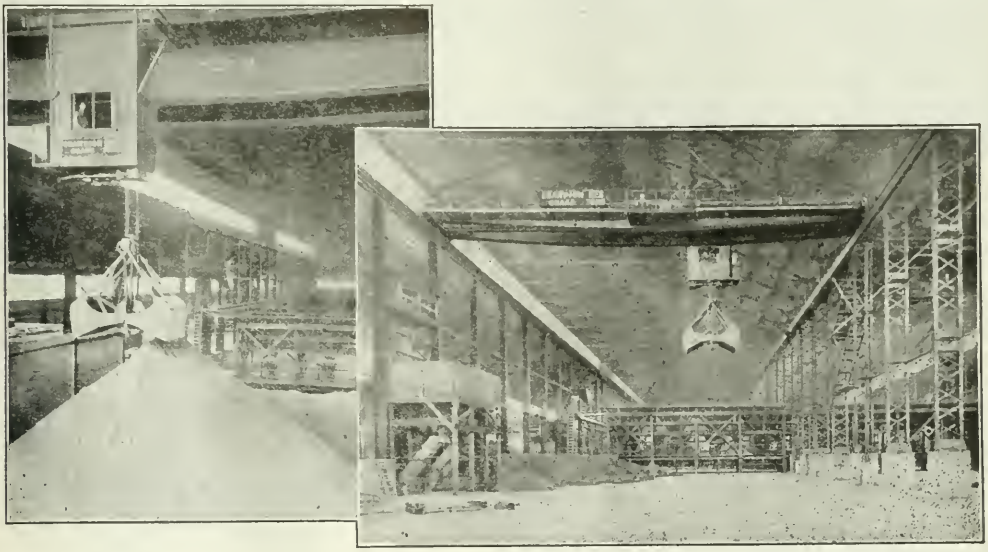
Although the booklet is chiefly devoted to C-H motor control apparatus, space is also given to other C-H products for the steel industry, including electric brakes, lifting magnets, space heaters, Thomas meters for measuring gases, and magnetic separator pulleys. The majority of the illustrations in the book show actual applications, these installation views being particularly interesting.

Announcement is made by the American Steam Conveyor Corporation of a change in its corporate name to the "Conveyors Corporation of America." The change in name is due to the rapid growth of the corporation, the addition of new lines of business and the purchase at South Bend, Ind., of a large and completely equipped machine shop to which foundry facilities will be added. The name more nearly describes the present business of the organization. The line includes steam jet conveyors for handling ashes, soot, combustion ash, etc., trolley carriers for handling coal, limestone, sand, gravel, and like loose bulky materials; ash pit doors, flood oil bearing sheaves and other conveyor supplies.

The War Memorial Scholarship committee of the Westinghouse Electric & Manufacturing Co. has announced as the winners of the four scholarships for the coming college year, 1920-21, Alva C. Corrao, small motor drafting department; Henry Gardnier Symonds, son of N. G. Symonds, manager industrial sales division, Chicago office; J. Dale Seabert, transformer engineering department, and Herbert R. Hillman, son of William A. Hillman, who has been a machinist in the works of the R. D. Nuttall Company for 27 years. These war memorial scholarships were established in 1919 as a means of perpetuating the memory of those employes of the Westinghouse Electric & Manufacturing Co. and its subsidiary companies, who took part in the war. Each scholarship carries with it the annual payment of $500 for a period not to exceed four years.

The Pennsylvania Pump & Compressor Co. announces the opening of additional sales offices as follows: Buffalo, 788 Pontiac avenue, J. B. Laird, Manager; Cleveland, 232 St. Clair avenue, N. E., L. J. Wakefield; St. Louis, 1956 Broadway, Carby Supply Company; Minneapolis, 423 Fifth avenue, South, L. E. Pallard Company; Omaha, 604 First National Bank Building, L. E. Pallard Company.

The Mesta Machine Company of Pittsburgh, Pa., has opened an office in the Singer Building, New York, from which point all its foreign business will be handled.



---and at Armour's

Three Champion Bucket Cranes are in continuous 24-hour service at the plant of The Armour Fertilizer Works at Chicago Heights, Ill. Other Champion Cranes are in operation at their Baltimore and Chrome, N. J., plants.

Each bucket holds three cubic yards and will handle ninety tons of fertilizer per hour—far quicker and more efficiently than the material could be shifted in any other way.

Our long experience in building bucket cranes has taught us how to solve the problems in the handling of fertilizer, cement, sand, coal, and other materials of similar character. The cranes themselves have the same smooth power as other types of Champion Cranes.

If you have a conveying problem our investigations and statistics will be of value to you.

The Champion Engineering Company

Kenton, Ohio.

New York
J. W. Spensley,
149 Broadway

Portland, Ore.
Portland Machy. Co.

Pittsburgh
Laughlin & Barney
819-21 Wabash Bldg.

Seattle
Hallidie Machy. Co.

CHAMPION CRANES

Toledo
W. C. Lloyd & Co.
1113 Second National Bank Bldg.

Philadelphia
Williams Machy. Co.
829 Commercial Bldg

San Francisco
Louis G. Henes,
76 Fremont St.

Los Angeles
Louis G. Henes,
Title Insur. Bldg.

Co-operate:—Refer to The Blast Furnace and Steel Plant

SITUATION WANTED
Mechanical Engineer & Designer

with ten years experience in Steel mills and power plants. Construction work open for engagement. Salary $240 a month.

ADDRESS R H B
Care The Blast Furnace and Steel Plant
108 Smithfield Street PITTSBURGH, PA.
111

WANTED

Six (6) first class experienced draftsmen familiar with general steel mill practice and construction. Applicants will please state in first letter age, nationality, whether married or single, locations where previously employed, salary required and time when can report for work. Steady positions offered to desirable applicants. All communications will be confidentially treated.

ADDRESS O C M
Care The Blast Furnace and Steel Plant
108 Smithfield Street PITTSBURGH, PA.
112

FOR SALE

3 Ton Whiting Pendant Hand Crane 30 ft span, 15 ft. lift. Good condition.
9x9 Curtis Air Compressor, almost new.

The Banner Machine Company,
COLUMBIANA, OHIO
114

MECHANICAL ENGINEER
College graduate, 12 years experience; last six years work along design of by-product recovery apparatus, coke oven and gas plants. Had experience in taking charge of responsible work and handling men on plant layout, design and detail.
ADDRESS BOX KB
Care The Blast Furnace and Steel Plant
108 Smithfield Street PITTSBURGH, PA.
111

WANTED
First class melter for steel foundry, using two-ton Heroult electric furnace. Must be experienced in acid operations. Location, eastern Pennsylvania.
BOX M S J
Care The Blast Furnace and Steel Plant
108 Smithfield Street PITTSBURGH, PA.
111

BLOWING ENGINES
FOR BLAST FURNACES

4 Wetherill Blowing Engines, steam cylinders 30", air cylinders 84" x 60" stroke, will maintain air pressure of 15 pounds, all complete and first class condition. Immediate delivery.

J. F. DONAHOO COMPANY,
BIRMINGHAM, ALA
tf

ANNEALING FURNACE
Quigley Oil Burning Car-Type.

Chamber 7 feet wide, 14 feet long, inside. Door opening one end, 7 feet wide by 55" high from top of car. Has two cars.

GILBY WIRE & DIE CO.,
Newark, N. J.
tf

WANTED
in First Class Condition
Hydraulic Forging Presses
Blast Furnace Gas Motors
Rolling Mill Equipment

(Blooming, Plate and Universal Mill)
Send Full Particulars and Terms.
No Transactions With Dealers.

Address Box M. A.
Care The Blast Furnace and Steel Plant
108 Smithfield St., PITTSBURGH, PA.
93

FOR SALE

New 72" Morton Traveling Head Plainer with all attachments. Has never been used.

ADDRESS F. C.,
Care The Blast Furnace and Steel Plant
108 Smithfield Street PITTSBURGH, PA.
f

RICHARDSON
for
RAILS

Constant stocks of New and Relaying Rails, Spikes and Bolts. Frogs and Switches. Tell us your requirements.

Richardson & Co., Inc.
2101 Oliver Building
PITTSBURGH, PA.

WANTED.

Thoroughly experienced and competent mechanical and structural engineer (rolling mill, blast furnace and general steel plant design, power house constructon, etc.), seeks connection with reliable concern n a capacity involving responsibility.

ADDRESS X. Y. Z.
Care The Blast Furnace and Steel Plant
108 Smithfield Street PITTSBURGH, PA.
f

POSITION WANTED

Technically trained man thoroughly experienced in all departments of by-product coke oven work, desires executive position in operating organization, or chance to work for promotion to such a position Can report on short notice.

Address:
932 Dover Ave., Dover, Ohio.
f

Electric Truck For Sale

One Type "G" Automatic Transportation Company electric truck, serial No. 343. Platform 36" wide by 66" long. Equipped with 36 Edison "A-4" cells. Cells and truck in good condition.

The Eastern Malleable Iron Company,
Naugatuck, Conn.
f

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Help and Positions Wanted—For Sale and Miscellaneous

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Page 7" x 10"	$40 00	$35 00
½ page—7" x 5" or 3½" x 10"	20.00	15 00
¼ page—2½" x 7" or 3½" x 5"	10.00	7.50
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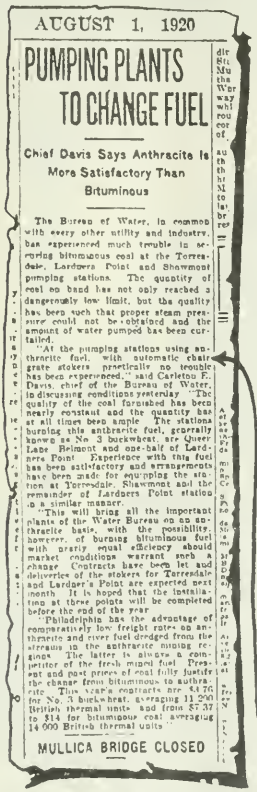
3 inches	6.00	4.50
2 inches	4.00	3.00
1 inch	2.00	1.50

Copy should be in publication office by 15th of each month for issue of 1st of following month. A copy of each issue containing advertisement is sent to advertiser. No extra charge. Remittance should accompany advertisement.

PHILADELPHIA

may be the butt of some wags as to being slow



AUGUST 1, 1920

PUMPING PLANTS TO CHANGE FUEL

Chief Davis Says Anthracite Is More Satisfactory Than Bituminous

The Bureau of Water, in common with every other utility and industry, has experienced much trouble in securing bituminous coal at the Torresdale, Lardyers Point and Shawmont pumping stations. The quantity of coal on hand has not only reached a dangerously low limit, but the quality has been such that proper steam pressure could not be obtained and the amount of water pumped has been curtailed.

"At the pumping stations using anthracite fuel, with automatic chain grate stokers practically no trouble has been experienced," said Carleton F. Davis, chief of the Bureau of Water, in discussing conditions yesterday. "The quality of the coal furnished has been nearly constant and the quantity has at all times been ample. The stations burning this anthracite fuel, generally known as No. 3 buckwheat, are Queen Lane Belmont and one-half of Lardyers Point. Experience with this fuel has been satisfactory and arrangements have been made for equipping the station at Torresdale, Shawmont and the remainder of Lardyers Point station in a similar manner.

"This will bring all the important plants of the Water Bureau on an anthracite basis, with the possibility, however, of burning bituminous fuel with nearly equal efficiency should market conditions warrant such a change. Contracts have been let and delivering of the stokers for Torresdale and Lardyer's Point are expected next month. It is hoped that the installations at these points will be completed before the end of the year.

"Philadelphia has the advantage of comparatively low freight rates on anthracite and river fuel dredged from the streams in the anthracite mining regions. The latter is given a competitor of the fresh mined fuel. Present and past prices of coal fully justify the change from bituminous to anthracite. This year's contracts are $4.76 for No. 3 buckwheat, averaging 11,200 British thermal units and from $7.37 to $14 for bituminous coal averaging 14,000 British thermal units.

MULLICA BRIDGE CLOSED

But—

The laugh is on the man who is using high priced coal—while the Quaker City cuts its per ton cost

From

$14.

to

$3.76

By installing

Coxe Stokers

Combustion Engineering Corporation

11 Broadway, New York City

Owners and manufacturers of

Type "E" Stokers—for Bituminous Coal — The Grieve Grate—Hand-Firing
Coxe Stokers—Anthracite Coal and Coke Breeze

PHILADELPHIA, PA. PITTSBURGH, PA. DETROIT, MICH. CHICAGO, ILL.
MINNEAPOLIS, MINN. BIRMINGHAM, ALA. HAZLETON, PA.
BOSTON, MASS SALT LAKE CITY, UTAH. ATLANTA, GA.
ALBANY N. Y. DENVER, COL. OMAHA, NEB. MILWAUKEE, WIS.
TAYLOR ENGINEERING CO., VANCOUVER, B. C.

Co-operate:—Refer to The Blast Furnace and Steel Plant

BLAW-KNOX

The Blaw Collier Bucket

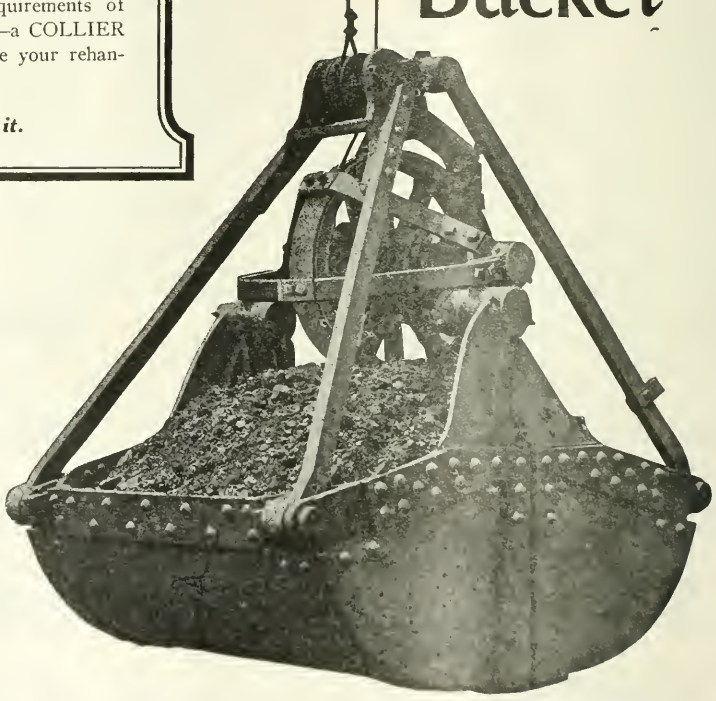
The Blaw Collier is a very light clamshell bucket—intended primarily for the purpose of rehandling coal, coke and anthracite—as its name implies.

The chief merit of the COLLIER is that it is very light for its scoop capacity, yet will pick up its rated load of run of mine, bituminous or semi-bituminous coal, or a heaping load of anthracite of ordinary sized lumps; slack; culm; crushed coal; ashes, etc.

For such services it is ideal.

Embodying all the requirements of strength and durability—a COLLIER installation will alleviate your rehandling problem.

Ask about it.



Note—These products are built and trade-marked by Blaw-Knox Company: Steel Forms for Concrete Construction—Clamshell Buckets—Fabricated Steel Specialties—Water-Cooled Appliances for High-Temperature Furnaces—Pressed, Riveted and Welded Plate Work—Standardized Sectional Steel Buildings

BLAW-KNOX COMPANY

PITTSBURGH, PA.
615 Farmers Bank Bldg.

New York - Boston - Chicago
Detroit - San Francisco - Baltimore

Co-operate:—Refer to The Blast Furnace and Steel Plant

The Cranes For Service

In addition to our line of Standard Cranes for every service from 5 to 200 tons capacity, we build more large and special types than all others combined. There is nothing in crane building too large or difficult for us to make.

ALLIANCE CRANES

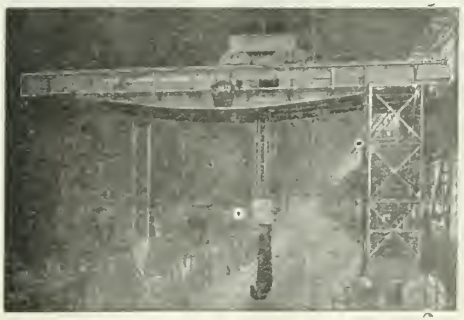
are the result of our vast experience in handling the difficult and unusual installations in the steel industry. The design and construction of Alliance Cranes, together with mechanical leadership and high grade workmanship have made us the largest manufacturers of the world's largest cranes.

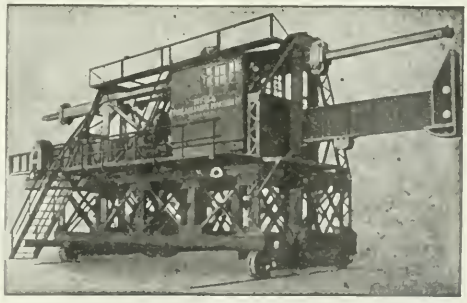
Write and tell us your problems.

The Alliance Machine Co.

Pittsburgh Alliance, Ohio. Birmingham

The World's Largest Builders of the World's Largest Cranes.





ECONOMY renewable FUSES

were the first line using an inexpensive bare link for restoring a blown fuse to its original efficiency to be approved ***In All Capacities*** by the Underwriters' Laboratories. This honor was not won on laboratory tests alone, but largely because for many years millions of Economy Fuses have been giving dependable protection, high efficiency and working marked economies. When you order fuses insist on ECONOMY.

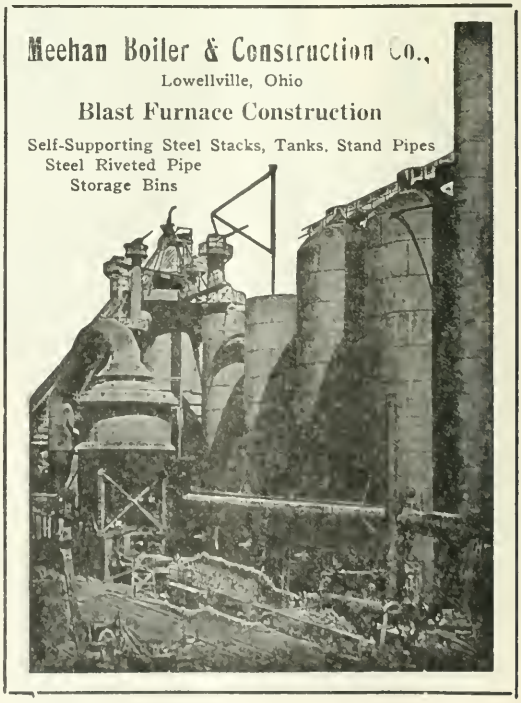
For sale by all leading electrical jobbers and dealers.

ECONOMY FUSE & MFG. CO.

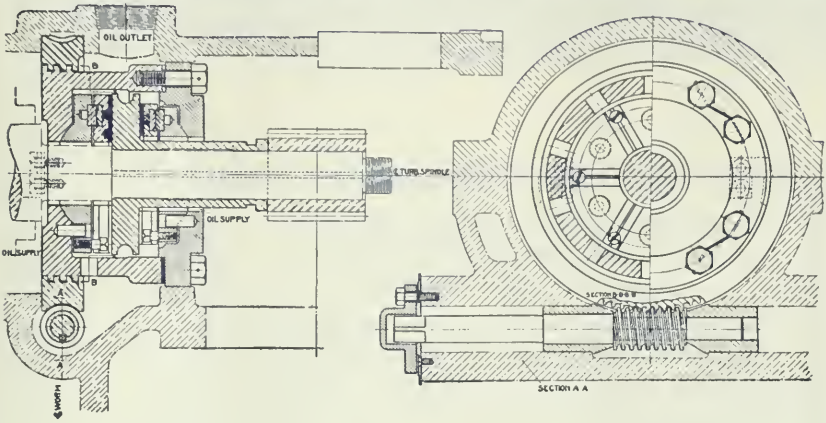
CHICAGO, U. S. A.

Economy Fuses also are made in Canada at Montreal

THE ONLY CENTER JET NOZZLE
What Would Happen if Your Water System Should Break Down?
A constant supply of thoroughly cooled water is guaranteed at all times by the
SPRACO COOLING POND
THE SPRACO CENTER JET NOZZLE IS
no others have it
NON-CLOGGING
Write for Bulletin No. C 8
Spray Engineering Co.,
BOSTON, MASS.
Mfgrs. also of Spraco Air Washers, Spraco Paint Guns and Cement Sprayers, Spraco Nozzles, Vaughan Flow Meters, etc.



Reliable, and Why—



The Kingsbury thrust bearing carries enormous loads per square inch of area because of the self-adjusting segments which set themselves at an angle with the plant of the thrust disc, corresponding to the thinning of the oil film as it is squeezed between the surfaces.

End Thrust—
and the Kingsbury Thrust Bearing

The strictly double-flow turbine, in which the steam divides equally and flows in both directions from the center has no end thrust.

Other designs have end thrust, and means must be provided to counter-act the thrust so that the rotor will remain in its correct axial position.

The Kingsbury Thrust Bearing, used on all Westinghouse turbines in which there is end thrust, possesses a degree of dependability exceeding any construction ever employed in this country.

500 lbs. per sq. inch may be carried indefinitely.

5,000 lbs. per sq. inch have been carried experimentally.

Installed on the Westinghouse Steam Turbine, the pressure commonly carried is about 300 lbs. per sq. inch

The illustration shows the construction of this bearing.

The extraordinary ruggedness and reliability of the Westinghouse Steam Turbine, are due to the thoroughness with which every detail has been carried out, and the large factor of safety employed in its design.

WESTINGHOUSE ELECTRIC & MFG. CO.
East Pittsburgh, Pa.

H-50

Westinghouse

AND NOW - "Pay for as

Here's How Diamond Soot Blowers Pay for Themselves in From Four to Six Months

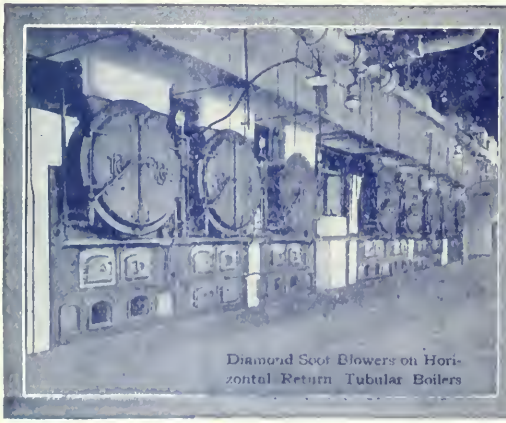
As compared to the best possible results obtained with the hand lance, Diamond Soot Blowers are today saving 4 to 8 per cent. fuel in thousands of power plants. As a typical illustration of the value of Diamonds, let us take the case of a certain manufacturer who operates four 500 H. P. horizontal water tube boilers. The boilers are driven at 150% rating, and average 6,000 hours per year in service. Coal costs $6 a ton delivered.

Before Diamond Soot Blowers were installed, the boilers required 13,250 lbs. of coal per hour. Now, 6.6 tons of coal per hour is 39,600 tons per year, and, on the old basis, this coal cost the Company $237,600.

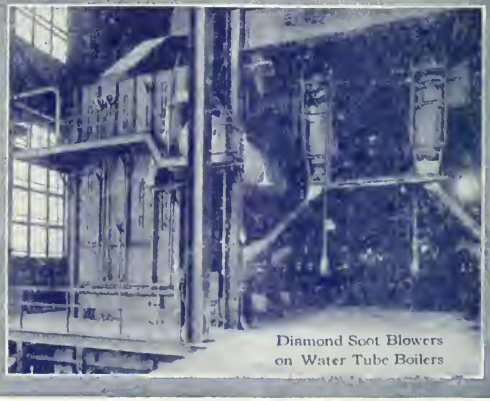
Since Diamonds have been installed, the fuel used per hour has been reduced to an average of 12,750 lbs. with the same load on the boilers. This a saving of 4 per cent., and amounts in money to about $9,000 over the course of a year.

In this case Diamond Soot Blowers completely paid for themselves in about four months time.

As conditions vary, no absolute rule can be set, but it is average experience that Diamonds completely return the investment in them in four to six or eight months time.



Diamond Soot Blowers on Horizontal Return Tubular Boilers



Diamond Soot Blowers on Water Tube Boilers

Co-operate:—Refer to The Blast Furnace and Steel Plant

Your Diamond Soot Blowers they Earn Profits"

A New Industrial Situation A New Plan

Cutting Production Costs is the *first* step in the return to normal conditions.

To enable the power plant operators of America to cut the cost of producing power, without impairing their working capital at a time when money is more or less difficult to obtain, we have evolved a new selling plan.

Here's the Plan:

The savings effected by Diamond Soot Blowers are as definite and positive as the proverbial "death and taxes." The economies include—4 to 8 per cent. reduction in fuel consumption—and 75 per cent. reduction in labor required for cleaning, to say nothing of the value of increased overall boiler efficiency, and decreased labor turnover in the fire-room resulting from improved conditions.

Based on fuel saving alone (see example on opposite page) Diamond Soot Blowers should pay for themselves in six to eight months. To enable every power plant operator to take advantage of these savings, we make the following offer:

> ***We will furnish Diamond Soot Blowers to equip as many boilers as desired by purchaser, accepting in exchange trade acceptances WITHOUT INTEREST covering the cost of the blowers, f. o. b, Detroit, one-half of the amount due to be paid in three months from date of invoice; the remainder in six months.***

This selling plan is unique in the power equipment field. We are glad thus to show our faith in the fundamental soundness of the American industrial situation. In this practical manner Diamond Soot Blowers are made available to every power plant operator.

The money which has first actually been saved in the purchase of fuel, should be enough approximately to pay for the blowers. This offer is of course made with present conditions in view and is subject to withdrawal without notice.

About Price

The price of Diamond Soot Blowers has advanced only 20 per cent. since May, 1917. In our campaign to keep prices down we have installed scientific production methods and have secured greatly increased distribution. The benefits have been passed directly to our customers. Since our prices have not been inflated *we cannot now lower them.* As a matter of fact to retain our present prices without increase we must maintain our present volume of output.

> *There is a Diamond Soot Blower for every type of boiler and every boiler needs one. For Full Information, ask for Bulletin 250.*

DIAMOND POWER SPECIALTY COMPANY
Detroit, Michigan

Diamond

SOOT BLOWERS - SAVE 4 to 8% FUEL

Co-operate:—Refer to The Blast Furnace and Steel Plant

Do You Realize the Great Expense of Packing Stuffing Boxes Today?

Everything Is Costly

The heaviest item of expense is the labor of applying the packing and not the packing itself.

It is therefore necessary that the heavy labor expense be minimized by using only the packing that gives the longest service.

Ask the Engineer who uses

"PALMETTO" PACKING

and he will tell you how long it outlasts other packings.

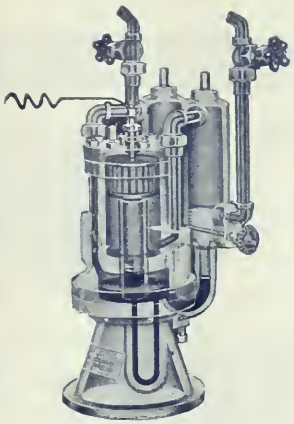
If you don't know what "PALMETTO" packing will do for you in the way of saving needless trouble, and useless expense, ask us to send you working samples to test under your own conditions. It will cost you nothing for the samples and it will prove our claim.

GREENE, TWEED & CO., Sole Manufacturers, 109 Duane St., N. Y.

REPUBLIC

ONLY ELECTRICALLY OPERATED

FLOW METERS



Electrical Operation Means Accuracy

—accuracy under every operating condition—for the electrical principle of operation (that exclusive feature of Republic Flow Meters) also widens their range.

No two piping systems are alike. Few applications for flow measurement present the same problem. Often points of measurement are so inaccessible that it is highly impracticable to situate reading instruments at the meter body on the pipe line. But the electrical principle of operation permits placing reading instruments any distance from the meter body without impairing their accuracy.

There is a *double* advantage in the principle of indicating steam flow by means of measuring the variation of an electric current—the principle found in the Republic alone:

The *delicate* differential pressure, the basis of all flow measurement, merely establishes contacts which naturally relay pressure variation to the reading instruments with the highest degree of accuracy. And since this dependable accuracy is *not* dependent on mechanical force, the reading instruments are *just* as accurate when located long distances from the meter body as when situated at the point of measurement.

FLEXIBILITY PLUS ACCURACY! That, briefly, is the result of electrical operation. It means that Republic Flow Meters will conform to your plant conditions—it means that you can *rely* on the indications of the reading instruments.

Write for complete explanation of the *benefits* of Flow Measurement and the *advantages* of the Republic.

REPUBLIC FLOW METERS CO.

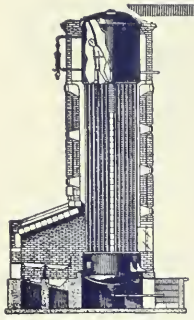
2240 DIVERSEY BOULEVARD

CHICAGO

New York Philadelphia Pittsburgh Boston Detroit Atlanta Toronto

Republic System

Co-operate:—Refer to The Blast Furnace and Steel Plant



Man stands erect while cleaning.

Wickes Vertical Water Tube Boiler

Ever cleaned a boiler, lamed your back, bruised your knees and skinned your elbows doing it?

Two men can open, wash, close and fill the WICKES in five hours.

Turbine in ten hours.

Ask for Bulletin—Reducing Costs in the Boiler Room—sent free.

THE WICKES BOILER COMPANY

SAGINAW MICHIGAN, U. S. A.

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Steel Cased Setting Increases Efficiency

Repairs to the Drums

in the Ladd Water Tube Boiler are practically nil.

There are no riveted seams in the path of the gases and such parts as are in contact with the gases are amply protected by circulating waters.

Our catalogue describing all the features and the advantages of the Ladd Boiler yours for the asking.

THE GEORGE T. LADD COMPANY,
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THREE AND FOUR WAY VALVES

MUD GUN HOLDING-DOWN MACHINES

MUD GUNS

THREE WAY TUYERE COCKS. Extra Heavy Design.

All styles.

BALL Unions, extra heavy, all styles. Three thread, fine thread and malleable nut. Catalogue upon request.

We can guarantee to make brass fittings inter-change in every way with ones you have in use.

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WATER TUBE STEAM BOILERS

STEAM SUPERHEATERS MECHANICAL STOKERS

Works: BARBERTON, OHIO BAYONNE, N. J

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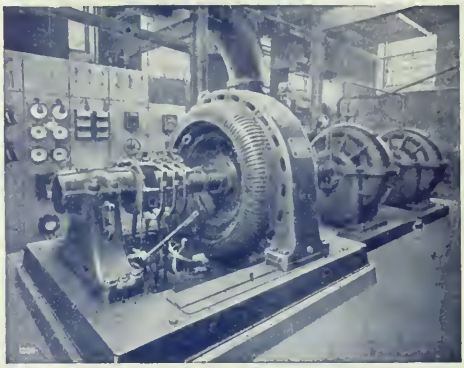
A NEW RECORD
82.5% COMBINED MOTOR AND PUMP EFFICIENCY

A "wire to water" efficiency of 82.5% is shown by two De Laval 24 in. pumps driven by a slip-ring induction motor in one of the pumping stations of the City of Minneapolis. The following figures relating to these pumps are from the official records of the City of Minneapolis.

Months	Gallons Pumped	Hours Run	Total Head	Efficiency
1918				
June	931,900,000	689.5	248.74	80.9
July	926,850,000	688.0	250.49	81.5
August	938,650,000	696.0	249.64	81.3
September	842,150,000	623.0	249.91	81.6
October	789,650,000	584.5	251.11	81.7
November	579,350,000	431.5	253.46	82.1
December	789,850,000	603.5	259.66	83.2
1919				
January	801,350,000	608.5	259.38	83.6
February	763,600,000	592.5	261.89	83.3
March	94,900,000	74.5	266.62	84.0
April	934,000,000	679.0	248.67	82.8
May	968,400,000	724.0	251.37	82.4
Totals	9,369,650,000	6,994.5	3,050.94	988.4
Monthly Average Year Ending May 31st, 1919	780,054,166.67	582.875	254.245	82.36 2/3
June, 1919				
	942,950,000	700.0	251.09	82.5



Two 24 in. De Laval Centrifugal Pumps handling 30,000,000 gal. per day against 250 ft. head and driven by a three-phase slip-ring induction motor.

Each De Laval centrifugal pump is guaranteed as to capacity and efficiency and is fully tested before shipment. We would take pleasure in estimating upon pumps to meet your requirements.

Now that our Government contracts are completed we are able to make prompt shipments.

DE LAVAL STEAM TURBINE CO., Trenton, N. J.

88

POWER PLANT TESTING

(Second Edition) By James A. Moyer, Director Extension Department Massachusetts Board of Education; 486 pages. 6 x 9; illustrated. Price $4.00 (Second Edition)

A complete treatise on the generally-approved methods used for testing engines, turbines, boilers and the auxiliary machinery found in the average power plant. It describes also the various kinds of apparatus used in testing.

CONTENTS:

I—Measurement of Pressure. II—Measurement of Temperature. III—Determination of Moisture in Steam. IV—Measurement of Areas. V—Engine Indicators and Reducing Motions. VI—Measurement of Power. VII—Flow of Fluids. VIII—Calorific Value of Fuels. IX—Flue Gas Analysis. X—Instructions Regarding Tests in General. XI—Boiler Testing. XII—Steam Engine Testing. XIII—Testlog of Steam Turbine and Turbine Generators. XIV—Methods of Correcting Steam Engine and Steam Turbine Tests to Standard Conditions. XV—Tests of Complete Steam Power Plants. XVI—Gas Engine and Producer Tests. XVII—Tests of Ventilating Fans or Blowers and Air Compression. XVIII—Tests of Refrigerating Machines. XIX—Tests of Hot Air Engines. XX—Tests of Hoists, Belts, Rope Drive and Friction Wheels. XXI—Tests of Lubricants. XXII—Tests of Hydraulic Machinery. XXIII—Tests of the Strength of Materials. XXIV—Outlines of Suggested Tests.

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Is your coal worth guarding? Our booklet "Fuel" will give you some valuable pointers.

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Michigan City, Ind.

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IT is easy to judge the size and quality of a visible commodity. There are certain recognized standards that have been universally accepted to which purchased articles may be compared.

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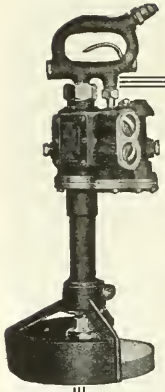
The A. B. C. now furnishes a recognized standard by which circulation may be measured. A publication's distribution can now be as accurately gauged as any other purchased commodity.

The The Blast Furnace and Steel Plant circulation is measured by the A. B. C. In buying advertising space in its columns, you receive dollar-for-dollar value.



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marvels of lightness, strength and durability. Designed and built by expert tool men and giving satisfaction in many of the largest plants in the country.

THOR Pneumatic Tools operate at a minimum cost and they are light and easy to handle; your men will delight in operating them.

THOR factories turn out the finest line of pneumatic and electrical tools on the market.

Write today and let us tell you more about them.

Independent Pneumatic Tool Company

Chicago, New York, Philadelphia, Boston, Pittsburgh, Cleveland, Detroit, Montreal, St. Louis, San Francisco, Birmingham, Toronto.

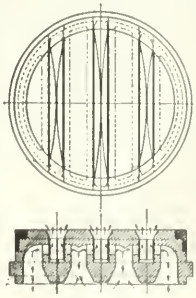
What can we do to improve the output and efficiency of our Blowing Engine?

By writing to the

Hope Engineering & Supply Co.

Mount Vernon, Ohio. **Pittsburgh, Pa.**

You can get information on the best plate valve ever constructed for high speeds.



The "Biplane" Valve, shown herewith, can be made in larger sizes and gives greater area with low lift than others. Complete heads as well as valves furnished.

Correspondence solicited

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The Saws That Cut

Day in and day out "SIMPLEX" INSERTED TOOTH SAWS give the same dependable service. No matter how tough the metal to be cut, no matter how severe the cutting strain, "SIMPLEX" SAWS never falter.

The wear resisting qualities of "SIMPLEX" SAWS are due to the high quality Crucible Alloy Steel used in their construction. They are tempered, ground and finished by experts. There is a "SIMPLEX" for every purpose. Let us recommend the saw for your work.

Our booklet on "Pittsburgh" Metal Cutting Saws will interest saw users. Have you a copy?

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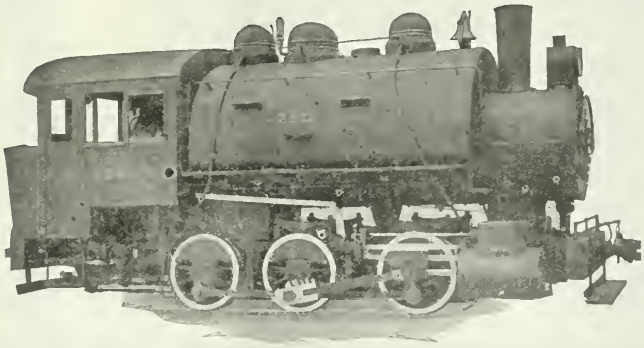

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PORTER Locomotives

Catalogue on request.

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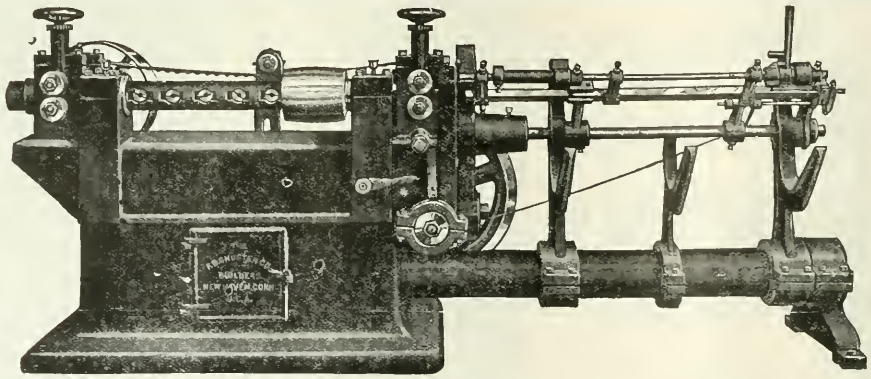


Started With One 40 Years Ago

and now have 21 in daily operation. This user writes us that they have always given satisfaction, and they must show a profit or the equipment would never have reached this number.

Our **Automatic Wire Straighteners and Cutters** handle all kinds of wire, make it **perfectly straight**, and cut lengths which are **absolutely accurate.**

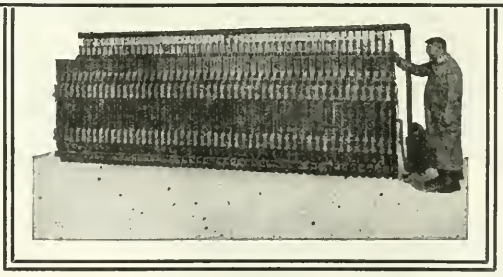
Half a century in building them has taught us to produce machines which meet every demand for this work.

May we quote on one to handle your work or send Catalogue.

THE F. B SHUSTER CO., NEW HAVEN, CONN.

formerly John Adt & Son — Established 1866

Also makers of Straighteners and Cutters for Squares, Hexagons, etc.



Purest Oxygen and Hydrogen at Less Than Half the Cost

Purity, Economy, Dependability are determining factors for consumers of Oxygen and Hydrogen.

An **I. O. C. System Oxygen Hydrogen Gas Generating Plant** installed in your works will secure them for you. The investment is reasonable.

Profit by the experience of others in your industry.

Let us figure on your requirements.

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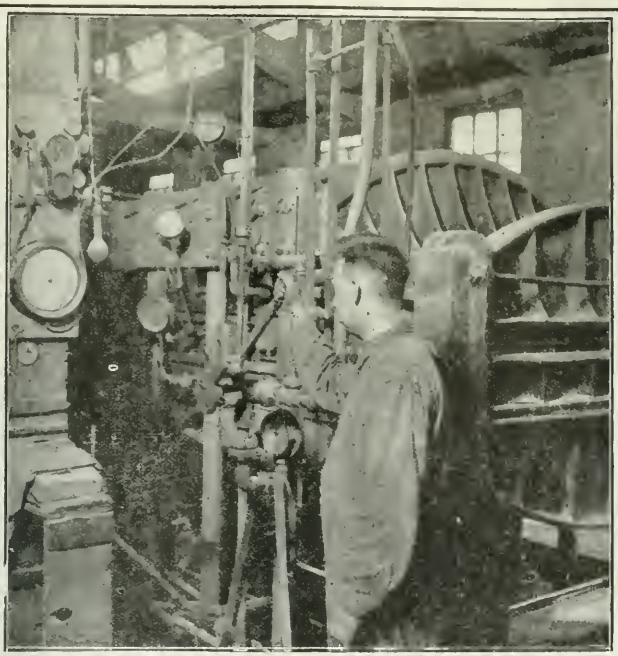

Yarway Hydraulic Valve installed on a horizontal press used for belts, packing, corrugated matting, etc., in a Trenton, N. J., plant.

"Accomplishes All You Claim For It"

"The two-pressure **Yarway Hydraulic Valve** which was installed some months ago accomplishes all you claim for it. We have sent you an order for two more. Our engineer, who has had long experience in the operation of valves, states that it is the best thing he has ever put in and it has his strongest endorsement." (Name on request.)

YARWAY

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(Caskey Patents)

For the high pressure and heavy duty of hydraulic machinery. Pressure-packed, and so constructed that the higher the pressure, the tighter the valve. Widely used in steel, rubber and other hydraulically equipped plants.

Bulletin H-2 contains full details. Shall we send you a copy?

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Offices in all Principal Cities.

A NEW TYPE OF ROLLING MILL PINION
TEETH ACCURATELY MILLED FROM A SOLID BLANK LEAVING SHROUDING FOR REINFORCEMENT AT ENDS AND NO TOOL CLEARANCE TO WEAKEN THE TOOTH AT APEX OF HELIX.
THE WOODARD MACHINE COMPANY
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CUT GEARS
SPUR, BEVEL AND HELICAL
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THE WOODARD MACHINE CO
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Conservation of Oil—

THE consumption of mineral oil products is increasing faster than the production. Consequently engineers are beginning to realize how important and necessary it is to conserve these oils.

A Bowser Oil Filtration System will assist you in doing this.

By filtering oil with a Bowser System it can be used over and over again, or indefinitely. The installation of a Bowser Complete Oil Filtering and Circulating System generally results in a saving of over 50 per cent on your oil bill.

Picture on right shows a practical application of a Bowser 6-F Oil Filtering and Circulating System. It can be used with engines and other machinery where the filtration of dirty oil is essential.

Write for our booklet on Oil Filtration.

S. F. Bowser & Co., Inc.
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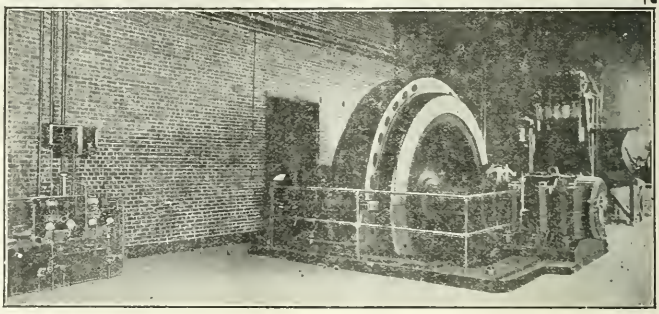

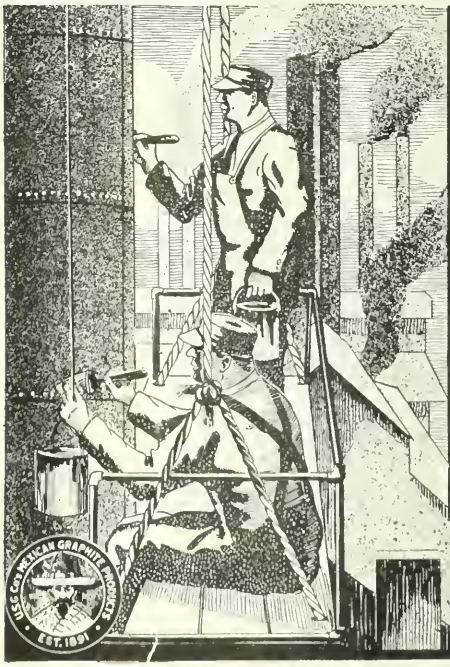

There's a U. S. G. Product for Every Steel Mill Use

Take for instance the protective coating for
BLAST FURNACES, HOT BLAST STOVES, CONNECTIONS, BOILER FRONTS, SMOKE STACKS, PIPES, ETC.

U S G Co's Mexican Graphite Paint

Resists corrosive influences longer and will cover more surface per gallon than any other paint on the market.
And because of its durability and lasting qualities it eliminates the necessity of frequent repainting and saves LABOR—the largest item of expense in painting.
The abnormally high cost of building material and labor makes timely painting a real economy.
Why not paint now and protect your property against acids, dampness and other destructive agents?
BOOKLET ABOUT "GRAPHITE PAINT" WILL BE OF INTEREST AND VALUE TO YOU. SEND FOR IT TODAY.

Other Graphite Products for Blast Furnace Use:
MOTOR AND GENERATOR BRUSHES NO. 205 LUBRICATING GRAPHITE MEXICAN BOILER GRAPHITE
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Largest Miners of Graphite on This Continent.

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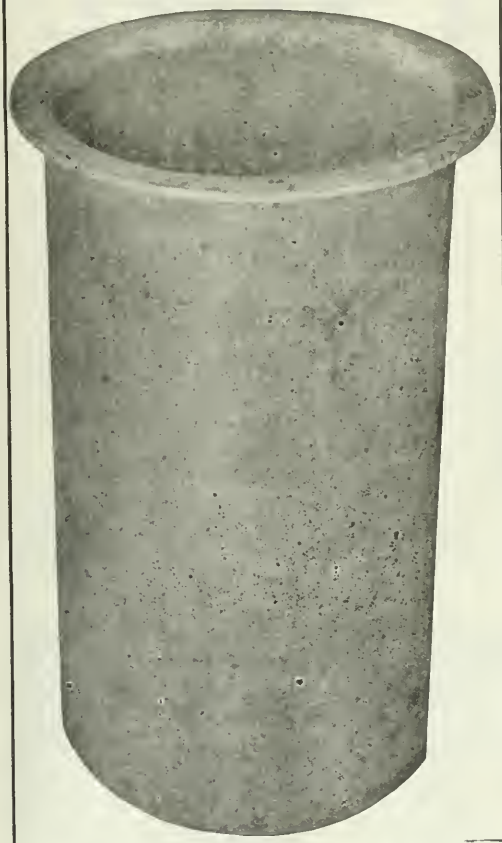

FORGE and HAMMER LAP WELDED ANNEALING POTS

Last Longer and Never Crack

The M. W. Kellogg Co.

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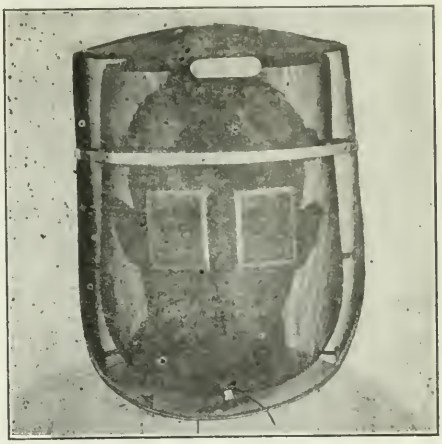
Pays for itself in the increased efficiency of the men



M-S-A (*De Rosier*) Heat Resisting Mask

In every blast furnace, about every steel plant, there is immediate need for this newest of masks.

In a word—it is light, comfortable, effective. The air blanket between the screens shields the face and entire head —turns the heat aside, prevents it from entering.

Best of all, your men will use this mask, use it regularly, for it means real comfort.

A complete equipment of these masks for the men in your plant will quickly pay for itself in increased efficiency.

Write, telephone or call for M-S-A Bulletin No. 58.

Mine Safety Appliances Company

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"Everything for Mine and Industrial Safety"

THE BRIER HILL STEEL CO.

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PLATES 5/16" TO 2" THICK 120 MAXIMUM WIDTH **BLUE ANNEALED** 16 GAUGE TO 1/4" THICK 72" MAXIMUM WIDTH **SHEETS** BLACK & GALVANIZED 10 GAUGE & LIGHTER

PICKLED STOCK

2" THICK & LIGHTER
72" MAXIMUM WIDTH
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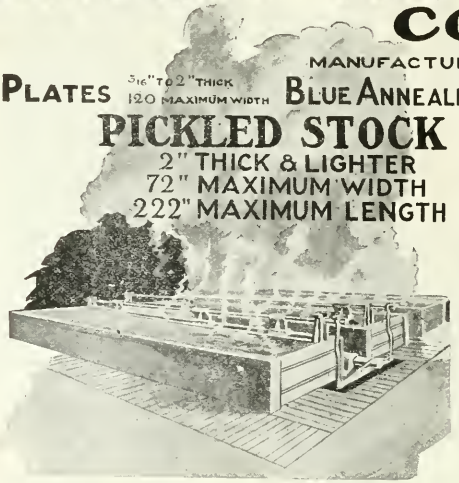

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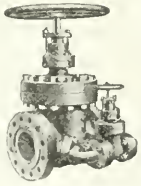

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ATWOOD

Heavier Standards For a Given Pressure

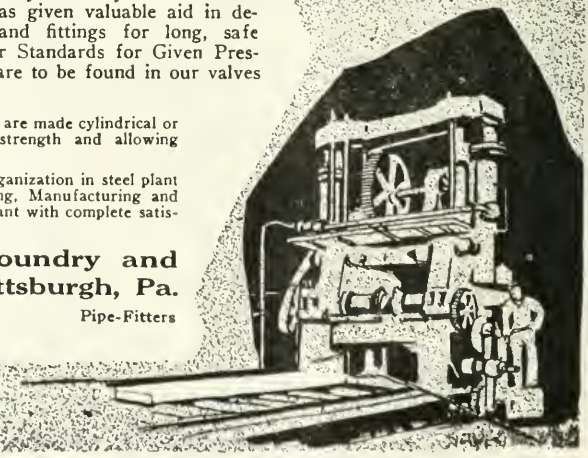
Data provided by carefully conducted destruction tests has given valuable aid in designing valves and fittings for long, safe service. Heavier Standards for Given Pressures therefore are to be found in our valves and fittings.

In our hydraulic valves, all surfaces are made cylindrical or spherical segments, giving maximum strength and allowing unrestricted flow within.

With the long experience of our organization in steel plant work you can rely on our Engineering, Manufacturing and Erecting Departments to equip your plant with complete satisfaction.

Pittsburgh Valve, Foundry and Construction Co., Pittsburgh, Pa.

Engineers Founders Machinists Pipe-Fitters



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ELECTRIC FURNACE CONSTRUCTION CO.

908 CHESTNUT STREET, PHILADELPHIA, PA.

We wish to announce that a new Department has been organized under George P. Mills, late of the General Electric Company. Orders are being executed for electrically heated annealing and heat treating furnaces—also core and mould drying ovens.

The "GREAVES-ETCHELLS" Furnace for "Quality" Steel—the pre-eminent steel-melting furnace.

We cordially welcome members of the Steel Treating Association to Philadelphia and shall be glad to see them at our Exhibition Booth No. 258, or at our offices, 908 Chestnut St.

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Prompt
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Repairs
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Broken
Crankshafts
Housings
Rolls
Pinions
Gears
Spindles
Hammers
and
Many Other
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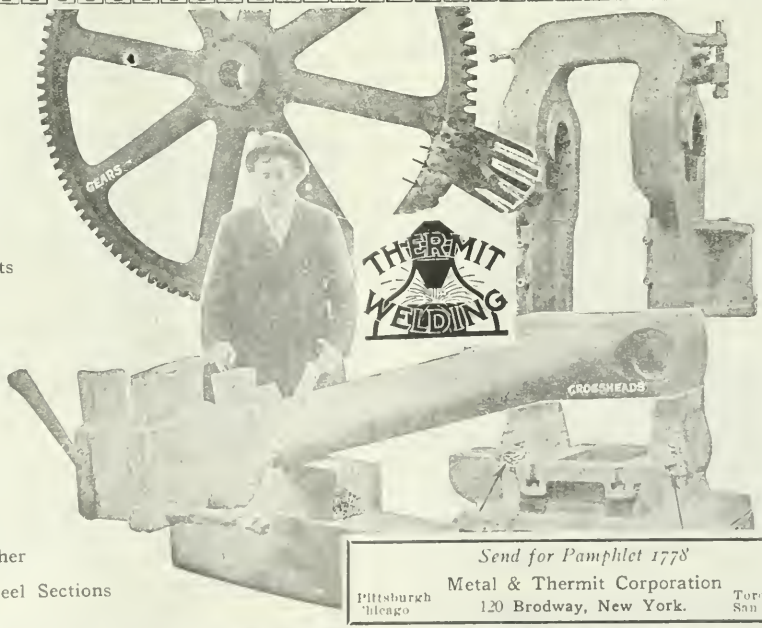

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Eliminate the costly sledge hammer method of removing slag and save time, money and labor.

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for removing slag from open hearth pockets. The use of this slag gun means time saved in getting the O. H. back into operation. Operates on air pressure of 75 pounds and up. Strikes a blow far more powerful than sledge. No complicated parts. Easy control. No kick. Write for details today. It will pay for itself in time saved.

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Spur, Bevel and Worm Gearing

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Special attention to quick repair work.

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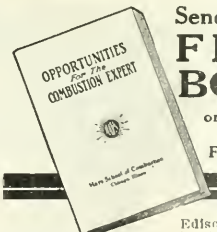

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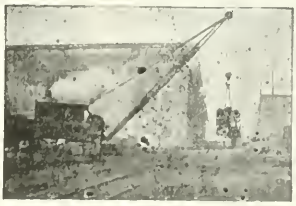

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and leading Industrial Concerns

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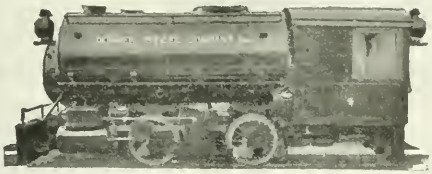

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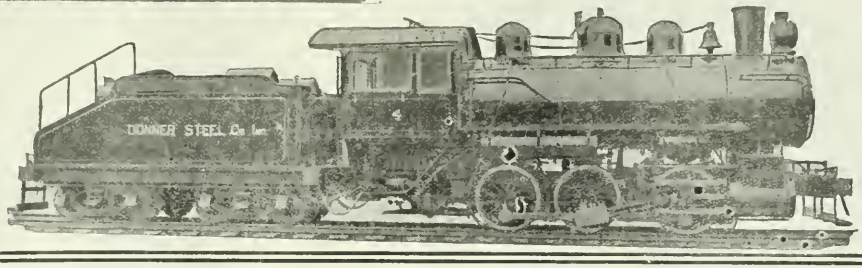

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PINIONS, FLEXIBLE COUPLINGS, MINE & INDUSTRIAL TROLLEYS.

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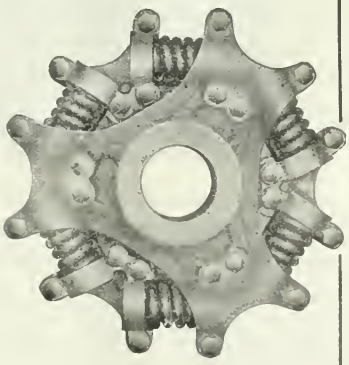

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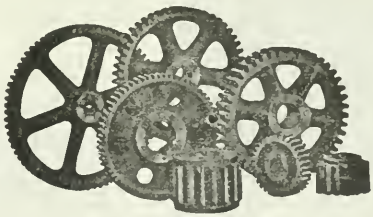

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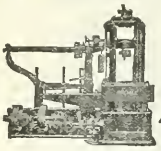
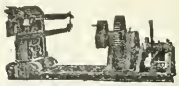

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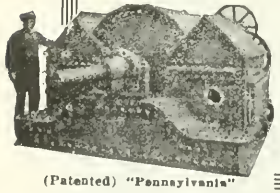

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Bradford Coal Cleaners for cleaning bituminous coals and reclaiming "gobbed" coals.

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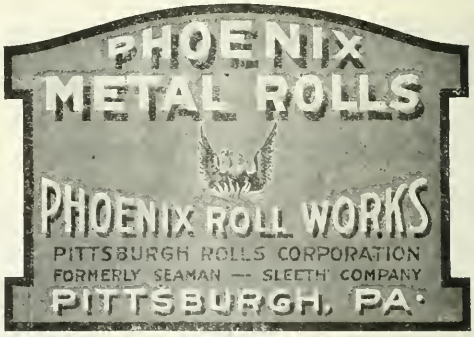

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Intense fuel burning efficiency—all the combustibles are completely burned and under conditions that produce the best results—is accomplished with the Fuller-Lehigh Pulverized Coal System. The Fuller-Lehigh System has developed through the study of many applications, most of them in the steel industry. It contains only those features absolutely necessary to the proper result, which accounts for its low first cost and upkeep. It removes the undesirable moisture in the coal and pulverizes it so that 85% of the pulverized coal will pass through meshes of 200 to the inch. Thoroughly mixed before burning the dry pulverized coal is fed by air-blast to the furnace. Temperatures can be readily and closely controlled.

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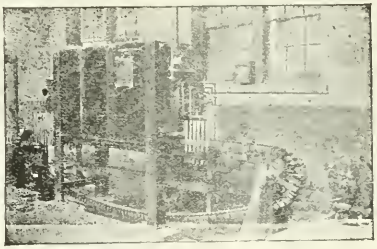

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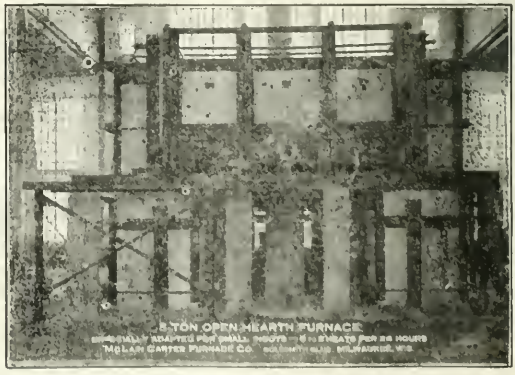

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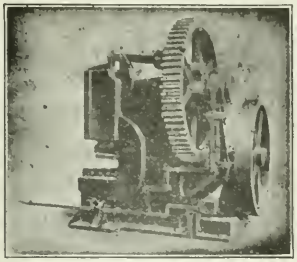

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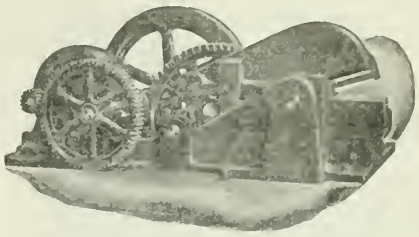

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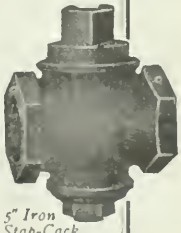

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Birdsboro Steel Fdy. & Mch Co.
Blaw-Knox Co.
Meehan Boiler & Construction Co.
Mesta Machine Co.
Quigley Furnace Specialties Co.
United Engineering & Fdy. Co.

Box Car Loaders.
Link-Belt Company.

Brass Cocks.
Chapman Valve Mfg. Co., The.

Bradford Breakers.
Pennsylvania Crusher Co.

Brakes—Electric, Magnetic, Crane.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.

Brakes—Disc.
Cutler-Hammer Mfg. Co.
Medart Patent Pulley Co.

Brakes—Motor Operated.
Cutler-Hammer Mfg. Co.

Brazing—Metal.
Pittsburgh Metal Brazing Co.

Brick—Chrome, Magnesia, Silica.
Amer. Enameled Brick & Tile Co.
American Refractories Co.
Bessemer Brick Co.
Harbison-Walker Ref. Co.
Mt. Union Refractories Co.
Mutton Hollow Fire Brick Co.
Pyro Clay Products Co.
Taylor, Chas., The Sons Co.

Brick—Blast Furnace.
Amer. Enameled Brick & Tile Co.
American Refractories Co.
Ashland Fire Brick Co.
Brighton Fire Brick Co.
Clearfield Fire Brick Co.
Dover Fire Brick Co.
Eureka Fire Brick Works.
Harbison-Walker Ref. Co.
Hydraulic Press Brick Co.
Kier Fire Brick Co.
Manown Mfg. Co.
Mt. Union Refractories Co.
Mutton Hollow Fire Brick Co.
Paterson Fire Brick Co.
Pyro Clay Products Co.
Solsson Fire Brick Co., Jos.
Taylor, Chas., The Sons Co.

Brick—Boiler Settings.
Amer. Enameled Brick & Tile Co.
American Refractories Co.
Ashland Fire Brick Co.
Brighton Fire Brick Co.
Clearfield Fire Brick Co.
Dover Fire Brick Co.
Harbison-Walker Ref. Co.
Hydraulic Press Brick Co.
Kier Fire Brick Co.
Mt. Union Refractories Co.
Mutton Hollow Fire Brick Co.
Paterson Fire Brick Co.
Pyro Clay Products Co.
Solsson Fire Brick Co., Jos.
Taylor, Chas., The Sons Co.

Brick—Fire.
Amer. Enameled Brick & Tile Co.
American Refractories Co.
Ashland Fire Brick Co.
Brighton Fire Brick Co.
Clearfield Fire Brick Co.
Crescent Refractories Co.
Dover Fire Brick Co.
Eureka Fire Brick Works.
Harbison-Walker Ref. Co.
Hydraulic Press Brick Co.
Kier Fire Brick Co.
Manown Mfg. Co.
Mt. Union Refractories Co.
Mutton Hollow Fire Brick Co.
Pyro Clay Products Co.
Solsson Fire Brick Co., Jos.
Taylor, Chas., The Sons Co.

Brick—Heat Insulating.
Amer. Enameled Brick & Tile Co.
Celite Products Co.
Eureka Fire Brick Works.
Mt. Union Refractories Co.
Mutton Hollow Fire Brick Co.
Pyro Clay Products Co.
Quigley Furnace Specialties Co.
Taylor, Chas., The Sons Co.

Brick—Locomotive Fire.
Amer. Enameled Brick & Tile Co.
Clearfield Fire Brick Co.
Dover Fire Brick Co.
Harbison-Walker Ref. Co.
Hydraulic Press Brick Co.
Mt. Union Refractories Co.
Mutton Hollow Fire Brick Co.
Pyro Clay Products Co.
Taylor, Chas., The Sons Co.

Brick—Nozzles, Sleeves and Runner.
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Bessemer Brick Co.
Manown Mfg. Co.
Mt. Union Refractories Co.
Mutton Hollow Fire Brick Co.
Pyro Clay Products Co.

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Scaife, Wm. B. & Sons Co.

Bars—Case Hardening and Carburizers.
Quigley Furnace Specialties Co.

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Kratzer & Co., W. N.
Meehan Boiler & Construction Co.
Mt. Vernon Bridge Co.

Brushes—Carbon, Graphite, Motor and Generator.
United States Graphite Co., The.

Bronze Gate Valves.
Chapman Valve Mfg. Co., The.

Buckets—Clam Shell, Grab or Orange Peel for Coal and Ore.
Blaw-Knox Co.
Edgar E. Broslus.
Link-Belt Company.
Penn Foundry & Mfg. Co.

Buckets—Elevator.
Link-Belt Company.

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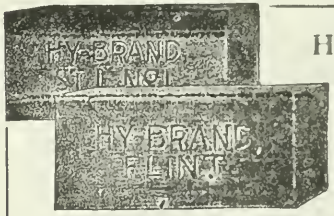

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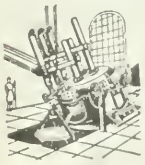

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Mt. Vernon Bridge Co.

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Blaw-Knox Co.
National Roll & Fdy. Co

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Garrison Foundry Co., A.
Morgan Construction Co.

Buoys.
Riter-Conley Co.

Burners—Gas and Oil.
Rockwell Co., W. S.

Burners—Powdered Coal.
Quigley Furnace Specialties Co.
Stroud, E. H. & Co.

By-Product Coke and Gas Oven Plants.
Koppers Co., The.

Cages—Hoisting.
R. H. Beaumont Co
Link-Belt Company.

Caissons.
Riter-Conley Co

Carbon Brushes.
Speer Carbon Co.
Martindale Electric Co., The

Carbon Dioxide Recorders.
The Jos. W. Hays Corp.

Carbon Monoxide Analyzers
The Jos. W. Hays Corp

Cars—Dump.
R. H. Beaumont Co.
Biehl Iron Works.
Clark Car Co.
Easton Car & Construction Co.
Link-Belt Company.
Penn Foundry & Mfg. Co.
Treadwell Engineering Co.
Whiting Foundry Equipment Co.
Youngstown Fdy. & Mch. Co.

Cars—Extensive Side Dump.
Clark Car Co.

Cars—Forging and Charging Box.
Easton Car & Construction Co.
Treadwell Engineering Co.

Cars—Hot Metal.
Blaw-Knox Co.
Easton Car & Construction Co.
Meehan Boiler & Construction Co.
Treadwell Engineering Co.
Youngstown Fdy. & Mch. Co.

Cars—Ingot—Slag—Billet.
Birdsboro Steel Fdy. & Mch. Co.
Easton Car & Construction Co.
Treadwell Engineering Co.

Cars—Industrial.
Biehl Iron Works, Inc.
Easton Car & Construction Co.
Penn Foundry & Mfg. Co.
Treadwell Engineering Co.
Whiting Foundry Equipment Co.
Youngstown Fdy. & Mch. Co.

Cars — Ingot and Open Hearth Charging.
Treadwell Engineering Co.

Cars—Ladle Transfer.
Easton Car & Construction Co.
Treadwell Engineering Co.
Youngstown Fdy. & Mch Co

Cars—Storage Battery.
Stroud, E. H. & Co

Car Tanks.
Riter-Conley Co

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D. & W. Fuse Works of General Electric Co.

Case Hardening Boxes.
Quigley Furnace Specialties Co.

Case Hardening Compound.
Quigley Furnace Specialties Co.

Castings—Annealed, Semi-Steel.
McLain's System, Inc.

Castings.
American Steel Foundries.
Birdsboro Steel Fdy. & Mch. Co.
Chambersburg Engineering Co.
Duquesne Steel Foundry Co.

Castings—Aluminum.
Penn Foundry & Mfg. Co.

Castings—Brass and Bronze.
Damascus Bronze Co.
Keystone Bronze Co.
Mesta Machine Co.
Morgan Engineering Co.

Castings—Chill.
McLain's System, Inc.

Castings—Electric Steel.
American Steel Foundries.
Birdsboro Steel Fdy. & Mch. Co.
Treadwell Engineering Co.
Wheeling Mold & Foundry Co.

Castings—Electric Process.
Treadwell Engineering Co.

Cast Steel Gate Valves.
Chapman Valve Mfg. Co., The.

Castings—Gear.
American Steel Foundries.
Birdsboro Steel Fdy. & Mch. Co.
Chambersburg Engineering Co.
Duquesne Steel Foundry Co.
Garrison Foundry Co., A.
Link-Belt Company.
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Mesta Machine Co.
Pittsburgh Iron & Steel Fdys. Co.
Standard Engineering Co.
Taylor-Wilson Mfg. Co.
Treadwell Engineering Co.
United Engineering & Fdy. Co.
Wheeling Mold & Foundry Co.

Castings—Semi-Steel.
Duquesne Steel Foundry Co.
McLain's System, Inc.

Castings—Gray Iron and Steel.
Garrison Foundry Co., A.
Link-Belt Company.
Morse Chain Co.
Otis Steel Co., The.
Penn Foundry & Mfg. Co.
Nuttall & Co., R. D.
Taylor-Wilson Mfg. Co.
Treadwell Engineering Co.

Castors—Plate Mill.
Edw. F. Terry Mfg. Co.
Treadwell Engineering Co

Cells—Generators, Hydrogen and Oxygen.
International Oxygen Co.

Cement—Fire Brick.
American Refractories Co
Bonfield Specialties Co.
Clinton Metallic Paint Co.
Crescent Refractories Co.
Quigley Furnace Specialties Co.

Cement—Furnace—High Temperature.
Clinton Metallic Paint Co.
Johns-Manville Co.
Quigley Furnace Specialties Co.

Cement—Pipe.
United States Graphite Co., The.

Central Station Equipment.
Allis-Chalmers Mfg. Co.
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Morgan Construction Co.
Smith Gas Engineering Co.
Westinghouse Electric & Mfg. Co.

Chains—Agricultural.
Link-Belt Co.
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Chains—Automobile, Engine.
Link-Belt Co.
Morse Chain Co.

Chain Blocks.
Morse Chain Co.

Chains—Bicycle (Twin Roller)
Morse Chain Co.

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Hagan, Geo. J. Co.

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Link-Belt Company.
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Chain Belt Co.
Link-Belt Company.
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Chains—Sprocket Wheel.
Link-Belt Co.
Morse Chain Co.

Chains—Silent.
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Treadwell Engineering Co.

Charging Boxes.
Riter-Conley Co.

Check Valves.
Chapman Valve Mfg. Co., The.

Chimneys—Steel.
Kratzer & Co., W. N.

Chrome.
Harbison-Walker Refractories Co.

Chrome Brick.
American Refractories Co.

Chromium.
Metal & Thermit Corp.

Circulating Systems for Lubricating Oil.
Bowser & Co., Inc., S. F.

Clamps—Flanging.
Chambersburg Engineering Co.
Niles-Bement Pond Co.
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Clutches—Magnetic.
Cutler-Hammer Mfg. Co.
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Coal.
Combustion Eng. Corp.
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Treadwell Engineering Co.
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Valley Mould & Iron Corp.
Wheeling Mold & Foundry Co.

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R. H. Beaumont Co.
Link-Belt Company.

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The Jos. W. Hays Corp

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Yarnall-Waring Co.

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United States Graphite Co., The

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Porter Co., H. K.

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Ingersoll-Rand Co.

Condensers—Surface.
Ingersoll-Rand Co.

Conduits—Elbow.
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Conduits—Electrical.
Youngstown Sheet & Tube Co.

Connectors—Frankel Solderless.
Westinghouse Electric & Mfg Co

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Westinghouse, Church, Kerr & Co., Inc.

Construction—Blast Furnace.
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Freyn, Brassert & Co.
Laughlin & Sons Co., Alex.
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McClure, G W & Son Co.
McKee, Arthur G. Co.
Mt. Vernon Bridge Co.
Smythe & Co., S R

Construction—Gas Works.
Blaw-Knox Co.
Morgan Construction Co.
McKee, Arthur G Co
Smith Gas Engineering Co.

Construction—Plate.
Blaw-Knox Co.
Meehan Boiler & Construction Co.
Mt Vernon Bridge Co.

Construction—Structural Iron, Steel
Blaw-Knox Co
Kratzer & Co., W N
Meehan Boiler & Construction Co
Mt. Vernon Bridge Co.

Construction—Wire Work.
Kratzer & Co., W N

Consulting Plant Engineers.
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Controllers—Enclosed Drum Type for Cranes.
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Electric Controller & Mfg Co
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Controllers — Manual, Automatic Machine Tool, Crane, Coal and Ore Bridges
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Conveyors—Billet
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Treadwell Eng Co.

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Champion Engineering Co
Morgan Engineering Co
Northern Engineering Works
Niles Bement Pond Co

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Alliance Machine Co
Champion Engineering Co
Link Belt Co
Morgan Engineering Co
Niles Bement Pond Co
Northern Engineering Works
Terry Edwards Mfg Co
Whiting Fdry & Equipment Co

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Link Belt Co.
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Whiting Fdry Equipment Co

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Cranes—Jib and Pillar
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Whiting Foundry Equipment Co.

Cranes—Coal and Ash Handling.
Link Belt Co.
Northern Engineering Works
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Whiting Foundry Equipment Co

Cranes—Locomotive
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Link Belt Company
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Link Belt Company
Mallard Patent Pulley Co
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Link Belt Company

Drives—Mill
Falk Co. The
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Link Belt Company.
Rockwell, W. S. Co.

Dynamos.
Allis Chalmers Mfg Co.
General Electric Co.
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Economizers—Fuel.
Green Fuel Economizer Co., The

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Bristol Co.
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General Electric Co.
Westinghouse Electric & Mfg Co.

Electrolytic Oxygen and Hydrogen Generators
International Oxygen Co.

Electric Welding
Pittsburgh Metal Brazing Co.

Electric Welding Apparatus.
Westinghouse Electric & Mfg. Co.
General Electric Co.

Elevators.
Link Belt Company.

Elevators and Conveyors.
Link Belt Company
Orton & Steinbrenner Co.

Electrodes—Carbon.
Speer Carbon Co

Engineering & Construction Service.
Westinghouse Church, Kerr & Co., Inc

Engineers—Consulting.
American Industrial Eng Co.
Duff Samuel K
Ellis, Frank J
Freyn & Co
Laughlin, Alex. & Co.
Meade, Richard K Co.
Arthur G. McKee Co.
McLain's System, Inc.
Moore, W K & Co.
Orth, Frank
Rockwell, W. S Co
Searing C A
Shover, Baring R.
Smythe Co., S R., The

Engineers—Furnace.
Electric Furnace Construction Co.
Moore, W K & Co
Orth, Frank
Pittsburgh Electric Fur. Corp.
Quigley Furnace Specialties Co.
Rockwell Co. W S

Engineers—Open Hearth.
Orth Frank

Engineers and Contractors.
Blair Engineering Co
Chamberlain Engineering Co.
Duff, Samuel K
Freyn, Brassert & Co.
Fuller Engineering Co.
Garrison Foundry Co.
Mesta Machine Co.
Mt. Vernon Bridge Co.
McClure Son & Co., G. W.
Arthur G McKee Co.
Laughlin, Alex. & Co.
Moore, W K & Co.
Orth, Frank
Riter Conley Co.
Rockwell, W. S. Co.
Smythe Co. S R, The
Standard Engineering Co.

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1914 36,000,000
1917 54,000,000
Capital
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Co-operate:—Refer to The Blast Furnace and Steel Plant

The Buyers' Guide

Treadwell Engineering Co.
Westinghouse, Church, Kerr & Co., Inc.
Robinson, Dwight P. Co.
Engineers—Consulting Plant.
Meade, Richard K. Co.
Engineering Instruments.
Taylor Instrument Co
Engines.
Allis-Chalmers Mfg. Co.
Mackintosh, Hemphill & Co
Mesta Machine Co
Engines—Gas.
Allis-Chalmers Mfg. Co.
Mesta Machine Co.
United Eng. & Foundry Co
Engines—Hoisting.
Mesta Machine Co.
Engines — Reversing, Blowing, Pumping, Gas.
Mackintosh, Hemphill & Co
Mesta Machine Co.
United Eng. & Foundry Co
Rockwell Co., W. S.
Engines—Steam.
Allis-Chalmers Mfg. Co.
Mackintosh, Hemphill & Co
Mesta Machine Co.
United Eng. & Foundry Co
Equipment—Coal Mine.
Link-Belt Company.
Equipment—Welded Chain, Wire and Wire Nail Mills—Complete.
Morgan Construction Co
Evaporators.
International Oxygen Co.
Expansion Joint.
Badger, E. B., & Sons Co
Nuttall, R. D. Co
Smith-Serrell Co.
Extra Heavy Gate Valves.
Chapman Valve Mfg. Co., The
Expanders—Tube.
Nicholson & Co., W H
Fabricated Steel.
Blaw-Knox Co.
Fans—Mechanical, Draft.
Green Fuel Economizer Co., The
Fencing Iron.
Kratzer & Co., W. N.
Fencing—Woven Wire.
Youngstown Sheet & Tube Co
Ferro-Alloys.
Metal & Thermit Corp.
United States Ferro Alloys Corp
Ferro-Silicon.
McKeefrey & Co.
Metal & Thermit Corp
FerroTitanium.
Metal & Thermit Corp
Ferro-Tungsten.
Metal & Thermit Corp
Ferro-Vanadium.
Metal & Thermit Corp
Ferro-Zirconium.
Metal & Thermit Corp
Filtering and Circulating Systems for Lubricating Oils.
Bowser & Co., Inc., S. F
Filters—Oil.
Bowser & Co., Inc., S F
Filtering Material.
Celite Products Co
Fire Brick Cement.
American Refractories Co.
Rotfield Specialties Co.
Clinton Metallic Paint Co
Crescent Refractories Co.
Hagan, Geo. J. Co
Quigley Furnace Specialties Co
Fire Clay.
Clinton Metallic Paint Co
Crescent Refractories
Fittings—Boiler.
Pittsburgh Piping & Equip Co
Fittings—Malleable and Cast Iron.
Pittsburgh Valve, Fdy. & Con. Co
Flexible Couplings.
Nuttall, R. D. Co
Smith-Serrell Co., Inc.
Flow Meters.
Cochrane, H. S. B. W. Corp
General Electric Co.
Republic Flow Meters Co.
Flour-Spar.
Matthew Addy Co., The.
Flue Gas Analyzers.
The Jos. W. Hays Corp
Forgings.
Biehl Iron Works, Inc.
Hagan, Geo. J. Co.
Heppenstall Forge & Knife Co
Heppenstall Forge Co.
Kratzer & Co., W. N.
Mesta Machine Co.
Morgan Engineering Co.
Penn Foundry & Mfg. Co
Forging Presses.
Garrison Foundry Co., A.
Morgan Engineering Co.
Niles-Bement-Pond Co.
Forms—Steel—for Concrete Construction.
Blaw-Knox Co.
Foundry Advisers.
McLain's System, Inc
Frames—Open Hearth.
Blair Engineering Co.
Blaw-Knox Co.
National Roll & Foundry Co.
Friction Blocks.
Morgan Construction Co.
Foundry Equipment.
Pittsburgh Valve, Fdy. & Con. Co.
Whiting Foundry Equip. Co.
Fuel Economizers.
Green Fuel Economizer Co., The
Fuel Oil.
Keystone Lubricating Co
Texas Co.
Furnace Alloys.
Stewart Iron Co.
Furnaces — Annealing and Case Hardening.
Electric Furnace Construction Co
Fuller Engineering Co.
Martindale Electric Co., The
W. S. Rockwell Co.
Furnace Builders.
American Industrial Eng. Co.
Blair Engineering Co.
Freyn, Brassert & Co.
Fuller Engineering Co.
Hagan, Geo. J. Co.
Hydraulic Press Brick Co
Laughlin, Alex. & Co.
Miller, W. R. Co., The
McClure Son & Co., G. W.
Arthur G. McKee Co.
Mt. Vernon Brick Co.
Pittsburgh Electric Fur. Corp
Pittsburgh Furnace Co.
Moore, M. E. & Co.
Rockwell, W. S. Co.
Smythe Co., S. R., The.
Furnace Equipment.
Blaw-Knox Co.
General Electric Co.
Rockwell, W. S. Co.
Furnaces—Forging, Heat Treating.
Hagan Geo. J. Co.
Leeds & Northrup Co.
Rockwell, W. S. Co.
Furnaces—Electric.
Electric Furnace Construction Co.
Leeds & Northrup Co.
Pittsburgh Electric Fur. Corp.
Pittsburgh Furnace Co.
Moore, M. E. & Co.
Quigley Furnace Specialties Co
W. S. Rockwell Co.
Furnace Engineers.
Moore, M. E. & Co.
Pittsburgh Electric Fur. Corp
Pittsburgh Furnace Co.
Furnaces—Heating.
Freeman Fire Brick Co.
Rockwell, W. S. Co
Furnace Insulation.
Celite Products Co.
Quigley Furnace Specialties Co
Furnaces—Lead, Pot and Muffle Annealing, Wire Mill.
Morgan Construction Co
Rockwell, W. S. Co.
Furnaces—Malleable.
Whiting Foundry Equipment Co
Furnaces—Metallurgical.
Fuller Engineering Co.
Moore, M. E. & Co.
Pittsburgh Electric Fur. Corp
Pittsburgh Furnace Co.
W. S. Rockwell Co.
Furnaces—Reheating.
Morgan Construction Co.
Rockwell, W. S. Co.
Furnaces—Automatic Smokeless.
Murphy Iron Works.
Rockwell, W. S. Co.
Fuses and Fuse Specialties.
D. & W. Fuse Works of General Electric Co.
Fuses.
D. & W. Fuse Works of General Electric Co.
Martindale Electric Co., The
Economy Fuse & Mfg. Co.
Fuses—Renewable.
D. & W. Fuse Works of General Electric Co.
Economy Fuse & Mfg. Co
Gas Analysis Apparatus.
The Jos. W. Hays Corp.
Gas—Hydrogen and Oxygen.
International Oxygen Co
Gages, Draft.
The Jos. W. Hays Corp
Gas Cleaning Plants.
Arthur G. McKee Co.
Gas Collectors.
The Jos. W. Hays Corp
Gas Producers.
Chapman Eng. Co.
The Koppers Co.
Laughlin, Alex.
Meehan Boiler & Constr. Co
Miller, W. R. Co., The
Morgan Construction Co.
Smith Gas Engineering Co
Smythe, S. R. Co.
Wood, R. D. & Co.
Gas Valves.
Blair Engineering Co
Felix McCarthy.
Rockwell, W. S. Co.
Gas Volome Meters.
Cutler-Hammer Mfg. Co
Gas Washers.
Freyn, Brassert & Co.
Spray Engineering Co
Gas Oven Plants.
Koppers Co., The.
Gasoline and Oil Measuring Tanks and Pumps—Oil.
Bowser & Co., Inc., S. F.
Gasoline Absorption Plants
The Koppers Co.
Gate Valves for Gas.
Chapman Valve Mfg. Co., The.
Gate Valves—Cast Steel.
Chapman Valve Mfg. Co., The
Gate Valves—Motor Operated.
Chapman Valve Mfg. Co., The
Gate Valves—Bronze.
Chapman Valve Mfg. Co., The.
Gauges—Oxygen Pressure.
International Oxygen Co
Gauges—Pressure, Draft, Volume.
Bristol Co
Gears—Bevel.
Fawcus Machine Co
Gears—Compensating.
Morse Chain Co.
Gears and Gear Cutting
Fawcus Machine Co
Falk Co., The
Link-Belt Company
Mackintosh, Hemphill & Co
Medart Patent Pulley Co
Mesta Machine Co
Morse Chain Co
Nuttall, R. D. Co.
The Simonds Mfg. Co
Taylor-Wilson Mfg. Co.
United Eng & Foundry Co
Woodard Machine Co
Gears—Herringbone.
Falk Co., The.
Fawcus Machine Co
Stewart, John A., Electric Co
Gear Guards.
Blaw-Knox Co
Gears—Spur.
Fawcus Machine Co
Gears—Spring.
Morse Chain Co
Gear Shield.
Ironsides Co., The
Gears—Worm.
Fawcus Machine Co.
General Industrial Construction.
McKee, Arthur G. & Co.
Generators—D. C. and A. C.
Allis-Chalmers Mfg. Co
General Electric Co.
Westinghouse Electric & Mfg. Co
Girders.
Kratzer & Co., W. N.
Meehan Boiler & Constr'n Co
Mt. Vernon Bridge Co.
Graphite—Boiler, Forging, Lubricant, Ingot Mold.
United States Graphite Co The
Grates.
Combustion Eng. Co
Greases.
Keystone Lubricating Co
Texas Co., The.
Ironsides Co., The.
Gulf Refining Co.
United States Graphite Co The
Grinders—Pneumatic & Electric
Independent Pneumatic Tool Co
Grinding and Polishing Machines.
General Electric Co.
Hammers—Board Steam and Steam Drop.
Chambersburg Engineering Co
Niles-Bement-Pond Co.
United Engineering & Fdy. Co
Hammer Crushers.
Pennsylvania Crusher Co.
Hammers—Pneumatic Chipping, Calking and Pipe Bending.
Independent Pneumatic Tool Co
Hauling Locomotives.
General Electric Co.
Westinghouse E. & M. Co.
Heads—Flanged and Dished Boiler.
Blaw-Knox Co.
Heads—Steel, Flanged and Dished.
Treadwell Construction Co
Hearth Jackets.
Blaw-Knox Co
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Robert Gordon, Inc.
Heaters—(Electric), Air, Space Water.
Cutler-Hammer Mfg. Co
Heat Insulation.
Celite Products Co.
Johns-Manville Co.
Quigley Fur. Spec. Co. Inc
Heat Treating Furnaces.
Electric Furnace Constr'n Co
Heat Treatment.
Nuttall, R. D. Co
Heatmeter.
Bristol Co.
Falk Co. The
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Allis-Chalmers Mfg. Co.
Link-Belt Company
Morgan Engineering Co.
Niles-Bement-Pond Co.
Northern Engineering Works.
Vulcan Iron Works.

Hoists—Mining.
Vulcan Iron Works.

Hoists—Monorail.
Link-Belt Co.
Northern Engineering Works.

Hoists—Portable.
Vulcan Iron Works.

Hoists—Skip.
Link-Belt Company

Hoists—Pneumatic.
Independent Pneumatic Tool Co

Holders—Gas.
Morgan Construction Co.
Smith Gas Engineering Co.

Holders—Pneumatic.
Independent Pneumatic Tool Co.

Hot Blast Stoves.
McKee, Arthur G & Co.

Hot Process Water Softeners.
H. S. B. W. Cochrane Corp.

Hoops.
West Leechburg Steel Co.
Youngstown Sheet & Tube Co

Hose—Pneumatic.
Independent Pneumatic Tool Co

Hydraulic Machinery.
Allis-Chalmers Mfg. Co
Birdsboro Steel Fdy & Mch Co

Hydraulic Valves.
Spray Engineering Co.
Yarnall-Waring Co.

Hydrants.
Chapman Valve Mfg Co., The.

Hydraulic Operated Gate Valves.
Chapman Valve Mfg Co., The.

Illuminators.
Hommel, Ludwig Co

Importer and Exporter.
Togaris Timoleon, P

Indicators—Continuous, Open or Closed Card.
Trill Indicator Co

Indicators—Draft, Pressure, Velocity.
Trill Indicator Co

Industrial Lighting
Hommel, Ludwig Co.

Industrial Track.
Penn Foundry & Mfg. Co.
Valley Mould & Iron Corp
Wheeling Mold & Fdy Co.

Inhalator—Oxygen.
Mine Safety Appliances Co

Instruments—Efficiency.
Bristol Co., The
General Electric Co.
Leeds & Northrup Co
Yarnall-Waring Co.

Instruments—Indicating and Recording.
Bristol Co., The
The Jos. W. Hays Corp.
Leeds & Northrup Co.
Yarnall-Waring Co.

Insulating Materials — Varnish, Sheeting, Tape Compound.
D. & W. Fuse Works of General Electric Co.

Insulating Materials—Heat.
Celite Products Co.
Johns Manville Co.
Quigley Furnace Specialties Co.

Insulating Brick and Powder.
Celite Products Co.
Clinton Metallic Paint Co.
Quigley Furnace Specialties Co.

Iron Body Bronze Mounted Gate Valves.
Chapman Valve Mfg Co., The.

Iron and Iron Ore.
Cleveland-Cliffs Iron Co.
McKeefrey & Co.
Stewart Iron Co.
Tod-Stambaugh Co

Iron Casings.
Valley Mould & Iron Corp

Iron Soldering (Electric)
Cutler-Hammer Mfg Co.

Joints
Metal & Thermit Corp

Kerosene.
Sloan & Zook

Kilns—Cement.
Blaw-Knox Co
Fuller-Lehigh Co

Kilns—Rotary.
Vulcan Iron Works

Ladles.
Biehl Iron Works Inc
Birdsboro Steel Fdy Mch Co
Blaw-Knox Co
Meehan Boiler & Constrn Co
Whiting Foundry Equip Co

Lathes—Roll.
Garrison Foundry Co., A
Mesta Machine Co
Niles-Bement-Pond Co
Pittsburgh Rolls Corporation.
Standard Eng Co
United Engineering & Fdy Co
United States Graphite Co., The

Lead.
United States Graphite Co. The

Lectromelt Rapid Steel Furnaces.
Pgh Electric Furnace Corp

Lifting Magnets.
Cutler-Hammer Mfg Co
Ohio Electric and Controller Co

Lighting Systems.
Hommel Ludwig Co.

Lime Kilns.
Meade Richard K Co

Limestone.
McKeefrey & Co

Limestone—Dryers and Pulverizers.
Fuller-Lehigh Co
Pennsylvania Crusher Co
Quigley Fur Spec Co, Inc

Linings—Brick.
Johns Manville Co.

Linings—Copola.
Amer Enam Brick & Tile Co
Ashland Fire Brick Co
Brighton Fire Brick Co
Clearfield Fire Brick Co
Dover Fire Brick Co
Harbison-Walker Ref Co
Kier Fire Brick Co
Manown Mfg Co
Mutton Hollow Fire Brick Co
Pyro Clay Products Co
Quigley Furnace Specialties Co
Salem Jos Fire Brick Co
Harbison-Walker Ref Co

Linings—Ladle
Amer Enam Brick & Tile Co.
Ashland Fire Brick Co
Brighton Fire Brick Co
Clearfield Fire Brick Co
Dover Fire Brick Co
Harbison-Walker Ref Co
Kier Fire Brick Co
Manown Mfg Co
Pyro Clay Products Co
Mutton Hollow Fire Brick Co
Quigley Furnace Specialties Co
Salem Jos Fire Brick Co
Taylor, Chas F

Liquid Level.
Bristol Co

Lubricants
Gulf Refining Co

Loaders — Wagon, Coal, Crushed Stone Rock Ore Ashes Etc.
Link Belt Company

Locomotives and Special Cranes.
Orton & Steinbrenner Co
U. S. Crane Co

Locomotives—Electric.
Atlas Car & Mfg Co.
Baldwin Locomotive Works
General Electric Co
Vulcan Iron Works
Westinghouse Elec & Mfg Co

Locomotives — Steam, Compressed Air Storage Steam
Porter, H K Co
Baldwin Locomotive Works
Vulcan Iron Works

Locomotives—Storage Battery.
General Electric Co.

Lubricants—Gear, Wire Rope, Etc.
Gulf Refining Co
Keystone Lubricating Co
Texas Co.
Ironsides Co., The
United States Graphite Co., The

Machinery—Clay.
Phillips & McLaren Co

Machinery—Hydraulic.
Allis-Chalmers Mfg Co
Birdsboro Steel Fdy & Mch Co
Chambersburg Engineering Co
Mesta Machine Co
Niles-Bement-Pond Co
Treadwell Engineering Co
United Engineering & Fdy Co

Machinery—Milling.
Cutler Hammer Mfg Co
Niles-Bement-Pond Co.

Machinery—Rolling Mill.
Birdsboro Steel Fdy & Mch Co
Garrison, A Foundry Co.
Mackintosh Hemphill & Co.
Mesta Machine Co
Morgan Construction Co
Morgan Engineering Co
National Roll & Foundry Co
Phillips & McLaren Co
Pittsburgh Rolls Corporation
Standard Engineering Co
Treadwell Engineering Co
United Engineering & Fdy Co
Wheeling Mold & Foundry Co
Woodard Machine Co
Youngstown Fdy & Mch Co

Machinery—Transmission (Power).
Link Belt Co
Morse Chain Co

Machinery—Special.
Cutler-Hammer Mfg Co
Garrison, A. Foundry Co
Niles-Bement-Pond Co
Southwark Foundry & Mch Co
Treadwell Engineering Co
Simonds Mfg Co, The
United Engineering & Fdy Co
Woodard Machine Co

Machinery—Tin Plate.
Garrison, A. Foundry Co
Mesta Machine Co
Northern Engineering Works

Machinery—Transmitting.
Link Belt Company
Mesta Machine Co
Morse Chain Co

Machinery—Wire Drawing, Wire and Rivet Works.
Morgan Construction Co
Webster Co, F B

Machinery and Supplies—Mining
Meehan Boiler & Constrn Co

Machinery—Wire Mill.
Morgan Construction Co

Machinery—Tin Plate.
Garrison Foundry Co., A
Mesta Machine Co
Northern Engineering Works

Machines—Straightening
Modern Patent Pulley Co
Morgan Construction Co
Niles-Bement-Pond Co
Webster Co, F B

Machines—Testing
Riehle Brothers Co

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Cutler-Hammer Mfg Co.
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Metal & Thermit Corp.

Manganese—Pure.
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General Electric Co.

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Hunter Saw & Machine Co.
Pittsburgh Saw & Mfg. Co.

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Pittsburgh Metal Brazing Co.

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Allen, A., & Son.
Damascus Bronze Co.
Keystone Bronze Co.
Lubricating Metal Co

Metals—Babbitt.
Allen, A., & Son.
Damascus Bronze Co.
Keystone Bronze Co.
Lubricating Metal Co.

Metallkase Magnesite Brick—McCallum Patent.
Harbison-Walker Refract. Co.

Meters—Flow.
General Electric Co.
Republic Flow Meters Co.

Meters—V-Notch (Independent)
H. S. B. W. Cochrane Corp.

Meters—Gas and Air.
Bacharach Industrial Inst. Co.
General Electric Co.
Cutler-Hammer Mfg. Co.

Meters for Oil—Kerosene, Gasoline.
Bowser S. F. & Co., Inc.

Meters—Recording.
Bristol Co., The.
Brown Instrument Co.
General Electric Co.
Leeds & Northrup Co.
Yarnall-Waring Co.

Meters—Weighing.
H. S. B. W. Cochrane Corp

Metering Heaters.
H. S. B. W. Cochrane Corp

Metals—Non-Ferrous.
Allen, A., & Son.
Damascus Bronze Co.
Metal & Thermit Corp.

Mill Brasses.
Acme Brass Foundry Co.

Mill Bearings—Roller.
Hyatt Roller Bearing Co
Morgan Construction Co.

Mills—Continuous Rolling.
Garrison, A. Foundry Co.
Mackintosh Hemphill & Co.
Mesta Machine Co.
Pittsburgh Iron & Steel Fdys. Co.
Standard Eng Co.
Treadwell Engineering Co
United Eng & Foundry Co

Mill Drives.
Falk Co., The
Fawcus Machine Co.

Mills—Blooming, Universal, Plate, Sheet, Tin and Bar.
Treadwell Engineering Co.

Mills—Wire, Complete Equipment.
Morgan Construction Co.

Mineral Seal.
Sloan & Zook

Mixers—"Blaw."
Blaw-Knox Co

Molds—Ingot.
Valley Mould & Iron Co.
Penn Mold & Mfg. Co.
Wheeling Mold & Foundry Co

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Co-operate:—Refer to The Blast Furnace and Steel Plant

The Buyers' Guide

Molybdenum.
Metal & Thermit Corp.
Monorail Systems—Electric.
Link-Belt Company.
Monorails—Overhead.
Link-Belt Company.
Niles-Bement-Pond Co.
Whiting Foundry Equipment Co.
Motors—Electric Steel Mill.
Allis-Chalmers Mfg. Co.
General Electric Co.
Stewart, John A., Electric Co.
Westinghouse Electric & Mfg. Co.
Motor Operated Brakes.
Cutler-Hammer Mfg. Co.
Mud Guns and Holding Down Machines.
McCarthy, Felix.
Nails.
Youngstown Sheet & Tube Co
Neutrals.
Sloan & Zook.
Nodulizing Kilns.
Vulcan Iron Works
Nozzles—Spray.
Spray Engineering Co.
Yarnall-Waring Co.
Oils—Engine.
Gulf Refining Co.
Ironsides Co.
Keystone Lubricating Co.
Texas Co.
Oil Engines.
Ingersoll-Rand Co.
Oils—Steam Cylinder Oils.
Gulf Refining Co.
Oil Filters.
Bowser, S. F. & Co., Inc.
Oil Fuse Cutouts (Aerial and Underground.
D. & W. Fuse Works of General Electric Co.
Oil Meters.
Bowser, S. F. & Co., Inc.
General Electric Co.
Oil Pumps.
Bowser S. F. & Co., Inc.
Oil Refineries.
Treadwell Construction Co.
Oil Storage and Distributing Systems.
Bowser, S. F. & Co., Inc.
Oil Tanks.
Bowser, S. F. & Co., Inc.
Open Feed Water Heaters and Receivers.
H. S. B. W. Cochrane Corp.
Open Feed Water Heaters.
H. S B. W. Cochrane Corp.
Ore.
McKeefrey & Co.
Stewart Iron Co.
Tod-Stambaugh Co.
Ores—Core.
Electric Furnace Construction Co.
Ore, Coal and Ash Handling Equipment.
Haywood Co.
Link-Belt Co.
McKee, Arthur G & Co.
Ore Roasting Kilns.
Vulcan Iron Works
Packing.
Green Tweed Co.
Johns Manville Co.
Paints—Metal and Wood.
Clinton Metallic Paint Co.
Koppers Products Co.
United States Graphite Co., The
Patents.
Siggers, E. G.
Whitaker, Norman T.
Penstocks.
Blair Engineering Co.
Blaw-Knox Co.
National Roll & Fdy. Co
Treadwell Construction Co.
Picks.
Oliver Iron & Steel Co
Pickling Tables.
Link-Belt Company.
Pig Iron.
McKeefrey & Co.
Stewart Iron Co.
Tod-Stambaugh Co.
Pile Drivers.
Vulcan Iron Works.
Pinions—Mill.
American Steel Foundries Co.
Birdsboro Steel Fdy. & Mch. Co.
Garrison, A., Foundry Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
National Roll & Foundry Co.
Nuttall, R. D. Co.
Pittsburgh Iron & Steel Fdys. Co.
Standard Engineering Co.
Otis Steel Co., The.
Simonds Mfg. Co.
United Eng. & Foundry Co.
Wheeling Mold & Foundry Co.
Woodard Machine Co.
Pipe.
Pittsburgh Piping & Equip. Co.
Youngstown Sheet & Tube. Co.
Pipe—Bends and Coils.
American Tube & Pipe Bending Co
Pittsburgh Piping & Equip. Co.
Taylor-Wilson Mfg. Co.
Pipe—Riveted Steel.
Blaw-Knox Co.
Meehan Boiler & Constr'n. Co.
Pipe—Wrought Iron.
Pittsburgh Piping & Equip. Co.
Reading Iron Co.
Youngstown Sheet & Tube Co.
Piping.
Pittsburgh Piping & Equip. Co.
Pittsburgh Valve, Fdy. & Con. Co.
Pipe Covering—Asbestos and Magnesia.
Celite Products Co.
Quigley Furnace Specialties Co.
Pipe Cutting and Threading Machines.
Standard Engineering Co.
Pittsburgh Piping & Equip. Co.
Taylor-Wilson Mfg. Co.
Pipe—Fittings.
Pittsburgh Valve, Fdy. & Con. Co.
Pipe Lines—Riveted Steel.
Treadwell Construction Co.
Pipe Mill Machinery.
Garrison, A., Foundry Co.
Pittsburgh Piping & Equip. Co.
Standard Engineering Co.
Taylor-Wilson Mfg. Co.
Treadwell Engineering Co.
United Engineering & Fdy. Co.
Piston Rods.
Hoppenstall Forge & Knife Co.
Hoppenstall Forge Co.
Plate and Structural Iron Work.
Easton Car & Construction Co.
Kratzer, W. N. & Co.
Otis Steel Co.
Plumbago.
United States Graphite Co., The
Pneumatic Tools.
Ingersoll-Rand Co.
Independent Pneumatic Tool Co.
Portable Track.
Easton Car & Construction Co.
Ports—Open Hearth.
Blair Engineering Co.
Blaw-Knox Co.
Birdsboro Steel Fdy. & Mch. Co.
National Roll & Fdy. Co.
Pots, Annealing—Forge and Hammer.
Kellogg, M. W. Co., The
Quigley Furnace Specialties Co
Pots, Annealing—Lap Welded.
Kellogg, M. W. Co., The
Pots—Cinder Slag.
Treadwell Engineering Co
Power House Conveyors.
Link-Belt Company
Power Plants.
McKee, Arthur G & Co
Power Transmitting Machinery.
Link-Belt Co.
Treadwell Engineering Co.
Powdered Coal Equipment.
American Industrial Eng. Co.
Fuller Engineering Co.
Fuller-Lehigh Co.
Quigley Furnace Specialties Co.
Stroud, E. H. & Co.
Powdered Coal Plants—Complete.
Fuller Engineering Co.
Quigley Furnace Specialties Co.
Precision Meters.
Cochrane H. S. B. W. Corp.
Presses—Forging.
Chambersburg Engineering Co.
Garrison, A., Foundry Co.
Mesta Machine Co.
Morgan Engineering Co.
Niles-Bement-Pond Co.
United Engineering & Fdy. Co.
Presses—Hydraulic.
Birdsboro Steel Fdy. & Mch. Co.
Camden Iron Works.
Canton Foundry & Machine Co.
Chambersburg Engineering Co.
Garrison, A., Foundry Co.
Mesta Machine Co.
Niles-Bement-Pond Co.
United Engineering & Fdy. Co
Vulcan Iron Works.
Presses—Rail Straightening.
Garrison, A., Foundry Co.
Morgan Construction Co.
Niles-Bement-Pond Co.
Pressure Packed Valves.
Homestead Valve & Mfg. Co
Spray Engineering Co.
Yarnall-Waring Co.
Pressure and Vacuum.
Bristol Co.
Producers—Gas Automatic.
Wood, R. D. & Co.
Miller, W. R. Co., The
Producers—Gas.
Blaw-Knox Co.
Chapman Eng. Co.
Laughlin, Alex. & Co.
Miller, W. R. Co., The
Morgan Construction Co.
Smith Gas Engineering Co., The
S. R. Smythe Co., The.
Wood, R. D. & Co.
Pulleys and Clutches.
Link-Belt Company.
Medart Patent Pulley Co
Mesta Machine Co.
Morse Chain Co.
Pulverizers.
American Industrial Eng. Co.
Fuller Engineering Co.
Fuller-Lehigh Co.
Pennsylvania Crusher Co.
Quigley Furnace Specialties Co
Stroud, E. H. & Co.
Pulverized Coal Equipment.
American Industrial Eng. Co
Bonnot Co., The.
Combustion Eng. Co.
Fuller Engineering Co.
Fuller-Lehigh Co.
Meade, Richard K. Co.
Quigley Furnace Specialties Co
Stroud, E. H. & Co.
Pumps—Air.
Ingersoll-Rand Co
Pumps.
Allis-Chalmers Mfg. Co.
Birdsboro Steel Fdy & Mch. Co
DeLaval Steam Turbine Co
Mesta Machine Co.
Richardson Prentx Co.
Pumps—Centrifugal.
Allis-Chalmers Mfg. Co
DeLaval Steam Turbine Co
Pumps—Electric.
Allis-Chalmers Mfg. Co.
Pumps (Hand or Power) — Oil, Gasoline.
Bowser, S. F. & Co., Inc
Pumps—Hydraulic.
Chambersburg Engineering Co
Punches—High Speed, Horizontal Multiple.
Niles-Bement-Pond Co
Pyrometers—Optical.
Leeds & Northrup Co.
Pyrometers—Indicating, Recording
Bacharach Industrial Inst. Co
Bristol Co., The.
The Jos. W. Hays Corp.
Leeds & Northrup Co.
Thwing Instrument Co.
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Railroad Scales.
Standard Scale & Supply Co
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General Electric Co.
Whiting Fdry. Equipment Co
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The Jos. W. Hays Corp.
Recording Thermometers.
Bristol Co.
The Jos. W. Hays Corp.
Leeds & Northrup Co.
Taylor Instrument Co.
Recording Instruments.
Bacharach Industrial Inst Co
Bristol Co.
The Jos. W. Hays Corp.
Leeds & Northrup Co.
Recording CO_2 Machines.
The Jos. W. Hays Corp.
Reels—Wood and Iron, Wire Mills.
Morgan Construction Co.
Refractory Linings and Cement.
Botfield Specialties Co.
Crescent Refractories Co.
Quigley Furnace Specialties Co
Seaboard Refractories Co.
Regulators.
Bristol Co.
Regulators—Automatic.
Bristol Co.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg Co
Leeds & Northrup Co.
Regulators, Dampers.
The Engineer Co.
Relays—Field Rheostat.
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Electric Controller & Mfg Co
General Electric Co.
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Economy Fuse & Mfg. Co.
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General Electric Co.
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Electric Controller & Mfg. Co
General Electric Co.
Rheostats—Motor Field, Motor Starting.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg Co
General Electric Co.
Riveters.
Chambersburg Engineering Co
Mesta Machine Co.
Niles-Bement-Pond Co
Rivet Cutting One.
Rivet Cutting Gun Co.
Riveted Piping.
Meehan Boiler & Constr. Co.
Heltzel Steel Form & Iron Co
Rocking Mill.
Mackintosh-Hemphill Co
Rod Mills.
Standard Engineering Co
Treadwell Engineering Co
Rods—Piston.
Hoppenstall Forge & Knife Co
Hoppenstall Forge Co.
Rolls—Crushing.
Link-Belt Company.
Pennsylvania Crusher Co
Stroud, E. H. & Co.
Rolls—Sand, Chilled and Steel.
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Birdsboro Steel Fdy. & Mch. Co
Duquesne Steel Foundry Co
Garrison, A., Foundry Co

Co-operate:—Refer to The Blast Furnace and Steel Plant

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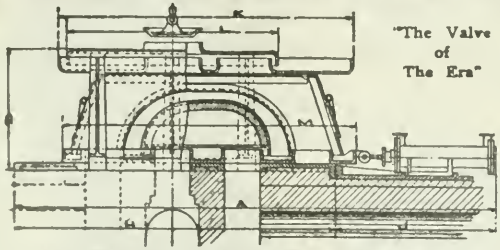

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Mesta Machine Co.
National Roll & Foundry Co.
Otis Steel Co.
Pittsburgh Iron & Steel Fdys. Co.
Pittsburgh Rolls Corporation.
Standard Engineering Co.
Canton Steel Foundry Co., The.
United Engineering & Fdy. Co.
Wheeling Mold & Foundry Co.
Youngstown Fdy. & Mch. Co.

Roll Bearings.

Damascus Bronze Co.
Keystone Bronze Co.

Roll Lathes.

Standard Engineering Co.

Roll Neck Lubricant.

Ironsides Co., The.

Roller Bearings.

American Roller Bearing Co
Hyatt Roller Bearing Co.

Rotary Kilns.

Vulcan Iron Works.

Rotating Electric Furnaces.

American Metallurgical Corp.

Rolling Mill Machinery.

Lewis Foundry & Machine Co.
Mesta Machine Co.
National Roll & Foundry Co.
Standard Engineering Co.
Treadwell Engineering Co.

Roofings—Fireproof.

Johns-Manville Co.

Roofs and Buildings—Iron.

Kratzer, W. N. & Co.
Mt. Vernon Bridge Co.

Rope Dressing.

Keystone Lubricating Co.
Link-Belt Company.
Texas Co.

Runners.

Valley Mould & Iron Corp.

Runner Brick.

Courtney Fire Brick Co.
Manown Manufacturing Co
Pittsburgh Coal Co.

Safety Appliances.

Mine Safety Appliances Co

Sand Filters.

H. S. B. W. Cochrane Corp.

Sand—Refractory.

Quigley Furnace Specialties Co.

Sand Rammers—Pneumatic

Independent Pneumatic Tool Co.

Saws — Metal Cutting, Inserted Tooth.

Pittsburgh Saw & Mfg. Co.
Standard Engineering Co.

Scales—Automatic Dial, Railroad Track, Special.

Standard Scale & Supply Co.

Scales — Rolling Mill, Furnace, Stock Charging.

Standard Scale & Supply Co.

Scientific Instruments.

Bristol Co.
Leeds & Northrup Co.

Screen—Perforated Metal.

Link-Belt Company.

Screens—Bar, Rotary or Shaking.

Link-Belt Company.

Screw Stock.

Standard Gauge Steel Co
Union Drawn Steel Co
West Leechburg Steel Co

Separators—Compressed Air.

H. S. B. W. Cochrane Corp

Separators—Steam.

Cochrane H. S. B. W. Corp.

Separators—Magnetic.

Cutler-Hammer Mfg. Co

Separators—Oil.

H. S. B. W. Cochrane Corp

Shafting.

Heppenstall Forge & Knife Co
Heppenstall Forge Co.
Medart Patent Pulley Co
Standard Gauge Steel Co
Union Drawn Steel Co
West Leechburg Steel Co

Shaft Couplings.

Link-Belt Co.
Smith & Serrell

Shaft Hangers.

Medart Patent Pulley Co

Shaking Screens.

Link-Belt Company.

Shapes—Special Steel.

Standard Gauge Steel Co.
Union Drawn Steel Co.
West Leechburg Steel Co.

Shears—Angle and Plate.

Garrison, A., Foundry Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Engineering Co.
Niles-Bement-Pond Co.
Phillips & McLaren Co.
Standard Engineering Co.
Treadwell Engineering Co.
United Engineerig & Fdy. Co.

Shear Blades.

Heppenstall Forge & Knife Co.
Heppenstall Forge Co.

Shears—Billet, Bloom and Slab.

Garrison, A., Foundry Co.
Lewis Foundry & Machine Co
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Engineering Co
Niles-Bement-Pond Co.
Phillips & McLaren Co
Quickwork Co.
Standard Engineering Co.
Treadwell Engineering Co.
United Engineering & Fdy. Co.
Woodard Machine Co.

Shears—Guillotine.

Garrison, A., Foundry Co.
Mackintosh, Hemphill & Co
Mesta Machine Co.
Morgan Engineering Co.
Phillips & McLaren Co.
Quickwork Co.
Standard Engineering Co.
Treadwell Engineering Co.
United Engineering & Fdy. Co

Shear Knives.

Heppenstall Forge & Knife Co.
Heppenstall Forge Co.

Shears—Portable, Motor Driven.

Garrison, A., Foundry Co.
Lewis Foundry & Machine Co
Mackintosh, Hemphill & Co
Mesta Machine Co.
Morgan Engineering Co
Phillips & McLaren Co.
Standard Engineering Co.
Treadwell Engineering Co.
United Engineering & Fdy Co

Shears—Scrap, Alligator, Wire.

Garrison, A., Foundry Co.
Lewis Foundry & Machine Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Engineering Co.
Phillips & McLaren Co.
Quickwork Co
Standard Engineering Co.
Treadwell Engineering Co.
United Engineering & Fdy Co
Youngstown Fdry. & Mch. Co.

Shears—Squaring.

Garrison, A., Foundry Co.
Mackintosh, Hemphill & Co
Mesta Machine Co
Niles-Bement-Pond Co.
Merchant & Evans Co.
Morgan Engineering Co.
Phillips & McLaren Co.
Standard Engineering Co.
Treadwell Engineering Co
United Engineering & Fdy Co.

Shearing Machines.

Garrison, A., Foundry Co.
Lewis Foundry & Machine Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co
Morgan Engineering Co.
Phillips & McLaren Co.
Standard Engineering Co
Treadwell Engineering Co

Sheets—Steel and Iron.

Otis Steel Co.
Merchant & Evans Co.
Youngstown Sheet & Tube Co

Silent Chain Drives.

Link-Belt Company.
Morse Chain Co.

Silica Brick.

American Refractories Co.
Harbison-Walker Refract. Co.

Silica Clays.

Harbison-Walker Refract. Co.

Silicon.

McKeefrey & Co.
United States Alloys Corp

Silicon—Ferro.

United States Alloys Corp.

Skip Hoists.

Link-Belt Company.
Treadwell Engineering Co

Skip Cars.

Atlas Car & Mfg. Co.
Riehl Iron Works, Inc.
Easton Car & Construction Co.
Youngstown Fdy. & Mch. Co.

Slag Cutter.

Rivet Cutting Gun Co.

Sleeves and Nozzles.

Courtney Fire Brick Co
Pittsburgh Coal Co.
Manown Manufacturing Co.

Sluice Gates.

Chapman Valve Mfg. Co., The.

Smoke Stacks—Steel.

Treadwell Construction Co.

Soaking Pit Covers.

Treadwell Engineering Co.
Wheeling Mold & Foundry Co.

Solder.

Damascus Bronze Co
Keystone Bronze Co

Solderless Connectors—Frankel.

Westinghouse Electric & Mfg. Co.

Spares—Open Hearth.

Riehl Iron Works, Inc.

Special Machinery.

Treadwell Engineering Co.

Spindles—Mill.

American Steel Foundries.
Bledsboro Steel Fdy & Mch. Co.
Mackintosh Hemphill & Co.
Mesta Machine Co.
Pittsburgh Rolls Corporation.
Standard Engineering Co.
Treadwell Engineering Co.
United Engineering & Fdy Co.
Wheeling Mold & Foundry Co.

Spray Nozzles.

Spray Engineering Co
Yarnall-Waring Co

Spray Cooling.

Spray Engineering Co.
Yarnall-Waring Co

Spray Water Cooling Equipment.

Badger, E. B. & Sons Co.
Yarnall-Waring Co.

Spray Air Washing Equipment.

Badger, E. B. & Sons Co.

Sprocket Wheels.

Link-Belt Company.
Medart Patent Pulley Co
Morse Chain Co.

Sprue Plates.

Valley Mould & Iron Corp

Stacks—Steel.

Blaw-Knox Co.
Meehan Boiler & Constr. Co.
Heltzel Steel Form & Iron Co.

Steam Packing.

Crane Packing Co.

Stampings—Steel.

West Leechburg Steel Co.

Standings — Water Cooled for Rolling Mill.

Blaw-Knox Co

Standpipes.

Blaw-Knox Co

Steam Stack and Cut-off Valve Heaters and Receivers.

H. S. B. W. Cochrane Corp.

Steam Superheaters.

Babcock & Wilcox Co.

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Nicholson, W. H. & Co.
Yarnall-Waring Co.

Steam Traps.

Homestead Valve Mfg. Co.
Nicholson, W. H. & Co.

Steel—Building and Structural.

Kratzer, W. N. & Co.
Mt. Vernon Bridge Co.
Toledo Bridge & Crane Co.

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Mt. Vernon Bridge Co.
Standard Gauge Steel Co.
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West Leechaburg Steel Co.

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Steel—Lap Weld.

American Tube & Pipe Bending Co.

Steel—Nickel.

Otis Steel Co., The.

Steel Plants.

McKee, Arthur G. & Co.

Steel—Seamless.

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Steel—Stamping and Drawing.

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Standard Gauge Steel Co.
Union Drawn Steel Co.
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Steel Plate Work.

Graver Corp.
Heltzel Steel Form & Iron Co.

Steel Plate Construction—Heavy.

Treadwell Construction Co.

Steel—Structural.

Kratzer, W. N. & Co.
Mt. Vernon Bridge Co.

Steel—Basic Open Hearth.

Brier Hill Steel Co.

Steel Plate Products—Pressed.

Meehan Boiler & Constr. Co.
Treadwell Construction Co.

Stills.

Blaw-Knox Co

Stills for Oil Refineries.

Treadwell Construction Co

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Stroud E. H. & Co.
Underfeed Stoker Co. of America

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The Engineer Co.

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Spray Engineering Co.
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McKee, Arthur G. & Co.

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No. 2—Photograph of a new Terry Wheel for comparison.

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Medart Patent Pulley Co.
Morgan Construction Co.
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Shuster, F. B. Co.

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Treadwell Construction Co

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Electric Controller & Mfg. Co.
General Electric Co.

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Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.

Switches—Magnetic.
Cutler-Hammer Mfg. Co.
General Electric Co.

Switches—Track.
Easton Car & Construction Co

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Morgan Construction Co.
Morgan Engineering Co.
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Woodward Machine Co

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Bristol Co.

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Biehl Iron Works, Inc.
Blaw-Knox Co.
Meehan Boiler & Const'n. Co.
Riter-Conley Co.

Tanks—Cast Iron.
H. S. B. W. Cochrane Corp.

Tanks—Oil, Gasoline, Kerosene.
Bowser, S. F. & Co., Inc.
Riter-Conley Co.

Tanks—Storage (Oxygen and Hydrogen.)
International Oxygen Co.
Riter-Conley Co.

Tanks—Storage and Pressure.
Graver Corp.
Riter-Conley Co.

Tanks and Towers—Steel.
Easton Car & Construction Co.
Blaw-Knox Co.
Riter-Conley Co.

Tapping Machines—Blast Furnace.
Southwark Fdry. & Mach. Co.

Tar Extractors.
Smith Gas Engineering Co.

Tar Distilling Plants
The Koppers Co.

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International Oxygen Co.

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Temperature Regulators
Bristol Co.
General Electric Co.
Leeds & Northrup Co.

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Bristol Co., The
Riehle Bros. Testing Mch. Co.

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Metal & Thermit Corp.

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Bristol Co., The
Leeds & Northrup Co.

Tie—Locomotive.
Dover Fire Brick Co.

Tin Plate Mill Equipment.
Treadwell Engineering Co.

Tipples—Coal.
Blaw-Knox Co.
Link-Belt Company.
Mt. Vernon Bridge Co.

Titanium.
Metal & Thermit Corp.

Tools.
Biehl Iron Works, Inc.
Camden Iron Works.

Tools—Roll Turning.
Garrison, A., Foundry Co.
Heppenstall Forge & Knife Co.
National Roll & Foundry Co.
United Engineering & Fdy. Co.
Pittsburgh Rolls Corporation.
Treadwell Engineering Co.
Standard Engineering Co.

Tools—Pneumatic.
Ingersoll-Rand Co.
Independent Pneumatic Tool Co

Tools—Electric.
Independent Pneumatic Tool Co.

Towers—Transmission, Galvanized
Kratzer, W. N. & Co.

Transformers.
General Electric Co.
Pittsburgh Transformer Co

Transfer Tables.
Whiting Foundry Equipment Co

Transmission—Rope.
Link-Belt Company.
Medart Patent Pulley Co.
Mesta Machine Co.
Morse Chain Co.
United Eng. & Foundry Co.

Transmission—Equipment.
General Electric Co.
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Link-Belt Company.
Mesta Machine Co.
Morse Chain Co.
United Eng. & Foundry Co.

Transmission—Silent Chain.
Chain Belt Co.
Link Belt Company
Morse Chain Co.

Transmission—Towers.
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Kratzer, W. N. & Co.
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Homestead Valve Mfg. Co
Spray Engineering Co.
Yarnall-Waring Co.

Trimmer Steel.
Heppenstall Forge & Knife Co
Heppenstall Forge Co.

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Easton Car & Construction Co.
Penn Foundry & Mfg. Co.
Standard Scale & Supply Co.
Whiting Foundry Equipment Co

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Mt. Vernon Bridge Co

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Combustion Eng. Co.

Tubes.
American Tube & Pipe Bend. Co.
Youngstown Sheet & Tube Co.

Tubes—Boiler, Superheater.
Youngstown Sheet & Tube Co.

Tumbling Barrels.
Babcock & Wilcox Co., The.
Whiting Foundry Equipment Co.

Tungsten.
Metal & Thermit Corp.

Turbines—Steam.
Allis-Chalmers Mfg. Co.
De Laval Steam Turbine Co.
General Electric Co.
Terry Steam Turbine Co.
Westinghouse Electric & Mfg. Co.
Stewart, John A., Electric Co.

Turbines—Power.
De Laval Steam Turbine Co.
General Electric Co.

Turbo—Blowers and Compressors.
De Laval Steam Turbine Co.
General Electric Co.
Ingersoll-Rand Co.

Turbo—Generators.
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General Electric Co.
Ingersoll-Rand Co.
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Easton Car & Construction Co.
Link-Belt Company.
Toledo Bridge & Crane Co.
Whiting Foundry Equipment Co

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Murphy Iron Works
Sanford-Riley Stoker Co.
Underfeed Stoker Co. of America

Unions.
McCarthy, Felix.
Homestead Valve Mfg. Co.
Youngstown Sheet & Tube Co.

Vacuum and Draft Gauges.
Bristol Co.

Valves.
American Fdy. & Const'n. Co.
Blair Engineering Co.
Blaw-Knox Co.
Chapman Valve Mfg. Co., The.
McCarthy, Felix.
Edward Valve & Mfg. Co.
Homestead Valve Mfg. Co.
Hope Engineering & Supply Co.
Pittsburgh Valve, Fdy. & Con. Co.
Rockwell, W. S. Co.
Richardson-Phenix Co.
Smythe, S. R. Co.
Spray Engineering Co.
Yarnall-Waring Co.

Valves—Atmospheric Relief.
H. S. B. W. Cochrane Corp.

Valves—Back Pressure.
H. S. B. W. Cochrane Corp

Valves—Blow-Off.
Homestead Valve Mfg. Co
Yarnall-Waring Co.

Valves—Check.
Chapman Valve Mfg. Co., The.
Cochrane, H. S. B. W. Corp.

Valves—Cast Steel.
Homestead Valve Mfg. Co.
Yarnall-Waring Co.

Valves—Gas.
Chapman Valve Mfg. Co., The.

Valves—Hydraulic.
Chapman Valve Mfg. Co., The.
Homestead Valve Mfg. Co.
Spray Engineering Co.
Yarnall-Waring Co.

Valves—Pump.
Edward Valve & Mfg. Co

Valves—Non-Return, Stop.
Edward Valve & Mfg. Co

Valves—Special.
Hope Engineering & Supply Co.
Pittsburgh Valve, Fdy. & Con. Co.
Miller, W. R. Co., The

Valves—Stud, Gas Cylinder.
International Oxygen Co.
Spray Engineering Co.
Yarnall-Waring Co.

Valves—Hydraulically Operated.
Chapman Valve Mfg. Co., The.

Valves and Fittings—Hydraulic.
Chambersburg Engineering Co
McCarthy, Felix.
Homestead Valve Mfg. Co.
Pittsburgh Valve, Fdy. & Con. Co
Spray Engineering Co.
Yarnall-Waring Co.

Valves—Motor-Operated.
Chapman Valve Mfg. Co., The
Spray Engineering Co
Yarnall-Waring Co

Valves—Reducing.
Edward Valve & Mfg. Co

Valves—Regrinding.
McCarthy, Felix.
Homestead Valve Mfg. Co.

Valves—Superheated Steam.
Edward Valve & Mfg. Co

Valves—Safety.
Edward Valve & Mfg. Co

Valves—Stop.
Edward Valve & Mfg. Co

Ventilating Apparatus.
Robert Gordon, Inc.

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Quigley Furnace Specialties Co
United States Graphite Co., The

Water Cooling—Apparatus.
Spray Engineering Co.
Yarnall-Waring Co.

Water Filters.
Graver Corp.
Scaife, Wm. B. & Sons Co

Water Heaters.
Cutler-Hammer Mfg. Co.
Graver Corp.

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Scaife, Wm. B. & Sons Co.

Water—Intake Screens—Traveling
Chain Belt Co.
Link-Belt Company.

Water Purifier.
Yarnall-Waring Co.

Water Tube Steam Boilers.
Babcock & Wilcox Co., The
Wickes Brothers C

Wedges,
Oliver Iron & Steel Co.

Welded Specialties and Headers.
Blaw-Knox Co.
Pittsburgh Valve, Fdy. & Con. Co

Welding and Cutting Apparatus—Oxy-Hydrogen.
International Oxygen Co

Welding.
Blaw-Knox Co.
Metal & Thermit Corp.
Pittsburgh Metal Brazing Co

Welding—Thermit.
Metal & Thermit Corp

Wheels.
Atlas Car & Mfg. Co.
Easton Car & Construction Co
Fuller-Lehigh Co.
Link-Belt Company.
Treadwell Engineering Co

Wheels—Car.
Easton Car & Construction Co
Fuller-Lehigh Co.
Treadwell Engineering Co

Wheels—Fly.
Link-Belt Company
Mesta Machine Co.
United Engineering & Fdy. Co

Wheels—Sheave.
Link-Belt Company
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Wire Mill Equipment.
American Ind. Eng. Co.

Wire Straightening Machines.
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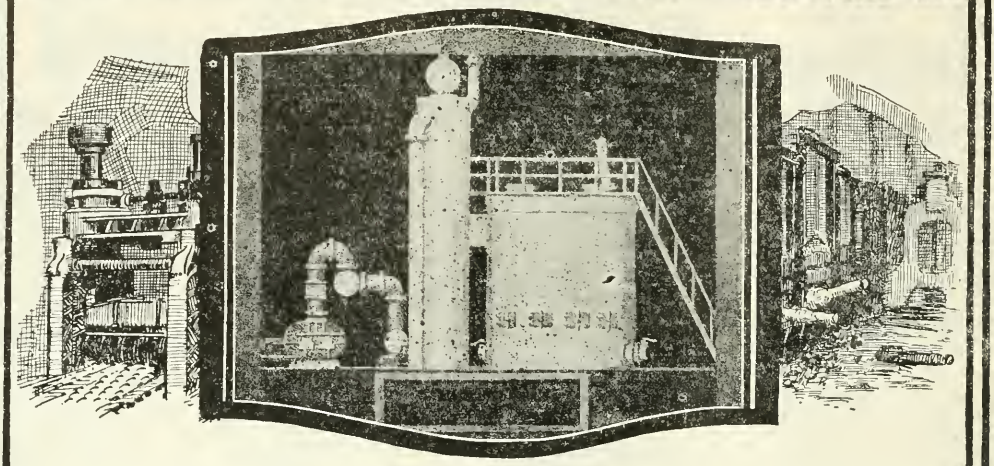

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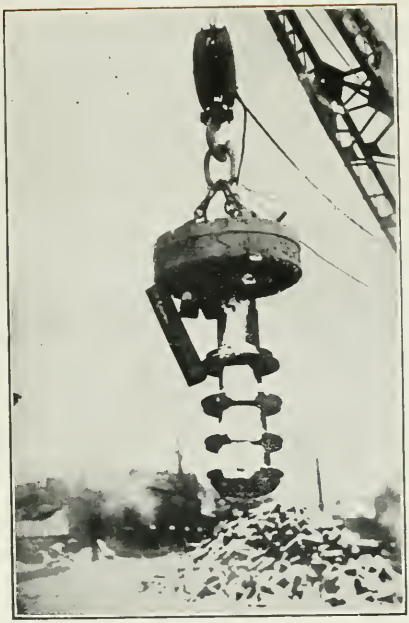

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Bulletin 104.

The Ohio Electric & Controller Co.,

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This picture only shows about one-third of the men loafing that afternoon as the rest of them refused to have their picture taken.

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Write for Bulletin 1025

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